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U.S. Geological Survey

MINERALS YEARBOOK

Metals and Minerals 2009

Volume I

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Marcia K. McNutt, Director

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Foreword

This edition of the U.S. Geological Survey (USGS) Minerals Yearbook discusses the performance of the worldwide minerals and materials industries during 2009 and provides background information to assist in interpreting that performance. Content of the individual Minerals Yearbook volumes follows:

- Volume I, Metals and Minerals, contains chapters about virtually all metallic and industrial mineral commodities important to the U.S. economy. Chapters on survey methods, summary statistics for domestic nonfuel minerals, and trends in mining and quarrying in the metals and industrial mineral industries in the United States are also included.
- Volume II, Area Reports: Domestic, contains a chapter on the mineral industry of each of the 50 States and Puerto Rico and the Administered Islands. This volume also has chapters on survey methods and summary statistics of domestic nonfuel minerals.
- Volume III, Area Reports: International, is published as four separate reports. These regional reports contain the latest available minerals data on more than 180 foreign countries and discuss the importance of minerals to the economies of these nations and the United States. Each report begins with an overview of the region's mineral industries during the year. It continues with individual country chapters that examine the mining, refining, processing, and use of minerals in each country of the region and how each country's mineral industry relates to U.S. industry. Most chapters include production tables and industry structure tables, information about Government policies and programs that affect the country's mineral industry, and an outlook section.

The USGS continually strives to improve the value of its publications to users. Constructive comments and suggestions by readers of the Minerals Yearbook are welcomed.

Marcia K. McNutt, Director

Contacts

Information about the U.S. Geological Survey, its programs, staff, and products may be accessed on the Internet at http://www.usgs.gov or by contacting the Earth Science Information Center at 1-888-ASK-USGS. For specific information about this publication, contact the Chief, Mineral Commodities Section, at (703) 648-4976; or the Team Secretary at (703) 648-4961. Additional minerals information may be accessed on the Internet at http://minerals.usgs.gov/minerals.

Acknowledgments

Volume I, Metals and Minerals, of the Minerals Yearbook presents data on more than 80 minerals and materials that were collected as a result of the information gathering activities of the U.S. Geological Survey.

The collection, compilation, and analysis of domestic mineral industry data were performed by the staff of the National Minerals Information Center. Statistical data were compiled from information supplied by mineral producers and consumers in response to canvasses, and their responses are greatfully appreciated. Information obtained from individual firms by means of the U.S. Geological Survey canvasses has been grouped to provide statistical aggregates. Data on individual firms are presented only if available from published or other nonproprietary sources or when permission of the respondent has been granted. The chapters on "Survey Methods of Nonfuel Minerals" and "Statistical Summary" discuss in greater detail procedures for canvassing the mineral industry and the processing and evaluation of these data. Other information appearing in this volume was obtained from the trade and technical press, industry contacts, and additional sources; this cooperation is gratefully acknowledged.

Statistics on world production were compiled from numerous sources, including reports from the U.S. Department of State. U.S. foreign trade data were obtained from reports of the U.S. Department of Commerce, U.S. Census Bureau. The U.S. Geological Survey also was assisted by numerous cooperating State agencies.

John H. DeYoung, Jr.
Director, National Minerals Information Center

Contents

Page

Foreword, by Marcia K. McNutt iii
Contacts iv
Acknowledgments, by John H. DeYoung, Jr. v
Survey methods for nonfuel minerals, by Jeffrey P. Busse 1.1
Statistical summary, by Joseph M. Krisanda 2.1
Mining and quarrying trends, by Mary E. Ewell 3.1
Abrasives, manufactured, by Donald W. Olson 4.1
Aluminum, by E. Lee Bray 5.1
Antimony, by James F. Carlin, Jr. 6.1
Arsenic, by William E. Brooks 7.1
Asbestos, by Robert L. Virta 8.1
Barite, by M. Michael Miller 9.1
Bauxite and alumina, by E. Lee Bray 10.1
Beryllium, by Brian W. Jaskula 11.1
Bismuth, by James F. Carlin, Jr. 12.1
Boron, by Marc A. Angulo 13.1
Bromine, by Lori E. Apodaca 14.1
Cadmium, by Amy C. Tolcin 15.1
Cement, by Hendrik G. van Oss 16.1
Chromium, by John F. Papp 17.1
Clay and shale, by Robert L. Virta 18.1
Cobalt, by Kim B. Shedd 19.1
Copper, by Daniel L. Edelstein 20.1
Diamond, industrial, by Donald W. Olson 21.1
Diatomite, by Robert D. Crangle, Jr. 22.1
Explosives, by Lori E. Apodaca 23.1
Feldspar and nepheline syenite, by Lori E. Apodaca and Arnold O. Tanner 24.1
Ferroalloys, by Lisa A. Corathers, Joseph Gambogi, Peter H. Kuck, John F. Papp, Désiré E. Polyak, and Kim B. Shedd 25.1
Fluorspar, by M. Michael Miller 26.1
Gallium, by Brian W. Jaskula 27.1
Garnet, industrial, by Donald W. Olson 28.1
Gemstones, by Donald W. Olson 29.1
Germanium, by David E. Guberman 30.1
Gold, by Micheal W. George 31.1
Graphite, by Donald W. Olson 32.1
Gypsum, by Robert D. Crangle, Jr. 33.1
Helium, by Norbert Pacheco and Deirdre Thomas 34.1
Indium, by Amy C. Tolcin 35.1
Iodine, by Marc A. Angulo 36.1
Iron and steel, by Michael D. Fenton 37.1
Iron and steel scrap, by Michael D. Fenton 38.1
Iron ore, by John D. Jorgenson 39.1
Iron oxide pigments, by Robert L. Virta 40.1
Kyanite and related materials, by Jason Christopher Willett 41.1
Lead, by David E. Guberman 42.1
Lime, by M. Michael Miller 43.1
Lithium, by Brian W. Jaskula 44.1
Magnesium, by Deborah A. Kramer 45.1
Magnesium compounds, by Deborah A. Kramer 46.1
Manganese, by Lisa A. Corathers 47.1
Mercury, by William E. Brooks 48.1
Mica, by M. Michael Miller 49.1
Molybdenum, by Désirée E. Polyak 50.1
Nickel, by Peter H. Kuck 51.1
Niobium (columbium) and tantalum, by John F. Papp 52.1
Nitrogen, by Lori E. Apodaca 53.1
Peat, by Lori E. Apodaca 54.1

Contents—Continued

Page

Perlite, by Wallace P. Bolen 55.1
Phosphate rock, by Stephen M. Jasinski 56.1
Platinum-group metals, by Patricia J. Loferski 57.1
Potash, by Stephen M. Jasinski 58.1
Pumice and pumicite, by Robert D. Crangle, Jr. 59.1
Rare earths, by Daniel J. Cordier 60.1
Recycling—Metals, by John F. Papp 61.1
Rhenium, by Désirée E. Polyak 62.1
Salt, by Dennis S. Kostick 63.1
Sand and gravel, construction, by Wallace P. Bolen 64.1
Selenium and tellurium, by Micheal W. George 65.1
Silica, by Thomas P. Dolley 66.1
Silicon, by Lisa A. Corathers 67.1
Silver, by William E. Brooks 68.1
Slag—Iron and steel, by Hendrik G. van Oss 69.1
Soda ash, by Dennis S. Kostick 70.1
Stone, crushed, by Jason Christopher Willett 71.1
Stone, dimension, by Thomas P. Dolley 72.1
Strontium, by Marc A. Angulo 73.1
Sulfur, by Lori E. Apodaca 74.1
Talc and pyrophyllite, by Robert L. Virta 75.1
Thorium, by E. Lee Bray 76.1
Tin, by James F. Carlin, Jr. 77.1
Titanium, by Joseph Gambogi 78.1
Tungsten, by Kim B. Shedd 79.1
Vanadium, by Désirée E. Polyak 80.1
Vermiculite, by Robert D. Crangle, Jr. 81.1
Wollastonite, by Robert L. Virta 82.1
Zeolites, by Robert L. Virta 83.1
Zinc, by Amy C. Tolcin 84.1
Zirconium and hafnium, by Joseph Gambogi 85.1

SURVEY METHODS FOR NONFUEL MINERALS

By Jeffrey P. Busse

The U.S. Geological Survey (USGS) collects worldwide data on virtually every commercially important nonfuel mineral commodity. These data form the basis for tracking and assessing the health of the minerals sector of the U.S. economy.

The USGS data collection activity was instituted by the 47th Congress in the appropriations act of August 7, 1882 (22 Stat. 329), which placed the collection of mineral statistics on an annual basis. The most recent authority for the USGS survey activity is the National Materials and Minerals Policy, Research and Development Act of 1980 (Public Law 96–479, 94 Stat. 2305). The Act included provisions to strengthen protection for proprietary data provided to the U.S. Department of the Interior by persons or firms engaged in any phase of mineral or mineral-material production or consumption.

Data Collection Surveys

The USGS begins the collection of domestic nonfuel minerals and materials statistics by appraising the information requirements of government and private organizations of the United States. Requirements that can be met by collecting data from minerals establishments are posed as questions on USGS surveys. Figure 1 shows a typical survey form.

Specific questions about mineral commodity activities, such as production, shipments, consumption, and recycling are structured in the survey forms to provide meaningful aggregated data. Thus, the entire mineral economic cycle from exploration and production through recycling is covered by approximately 150 monthly, quarterly, semiannual, and annual surveys.

After the survey form has been designed, a list of the appropriate establishments to be canvassed is developed. Many sources are used to determine which companies, mines, plants, and other operations are included on the survey mailing list. State geologists, Federal organizations (such as the Mine Safety and Health Administration), trade associations, industry representatives, and trade publications and directories are some of the sources that are used to develop and update survey listings. With few exceptions, a complete census of the list of establishments is used rather than a sample survey.

The Paperwork Reduction Act requires that any Government agency that wants to collect information from 10 or more individuals or establishments must first obtain approval from the Office of Management and Budget (OMB), which approves the need to collect the data and protects industry from unwarranted Government paperwork. This approval is indicated by the OMB control number on the survey forms (figure 1).

Survey Processing

The USGS surveys approximately 20,000 establishments. Each year, the USGS mails about 32,000 forms for approximately 150 different surveys. Each completed survey form returned to the USGS undergoes extensive analysis, including computerized checks, to ensure the highest possible accuracy of the mineral data. The statistical staff monitors all surveys to ensure that errors are not created by reporting in physical units different from the units requested on the form. Relations between associated measures, such as produced crude ore and marketable crude ore, are analyzed for consistency. Engineering variables, such as recovery factors from ores and concentrates, also are used. The totals for each form are verified, and currently reported data are checked against prior reports to detect possible errors or omissions.

The USGS has developed a Web-based electronic forms system as required by the Government Paperwork Elimination Act (GPEA). This electronic system was designed to speed the collection and analysis of minerals information. As of December 2009, approximately 100 canvass forms, accounting for all the annual responses covered by GPEA, are available electronically.

Survey Responses.—To enable the reader to better understand the basis on which the statistics are calculated, each mineral commodity chapter includes a section about domestic data coverage. This section briefly describes the data sources, the number of establishments surveyed, the response percentage, and the method of estimating the production or consumption for nonrespondents.

To produce reliable aggregated data, the USGS uses efficient procedures for handling instances of nonresponse. Failure to respond to the initial survey form results in a second request, in the form of either a second mailing of the paper form or an email in the case of electronic respondents. If the second request does not produce a response, then telephone calls are made to the nonrespondents. The followup calls provide the necessary data to complete the survey forms and (or) to verify questionable data entries. Periodic visits to mineral establishments also are made by USGS mineral commodity specialists to gather missing data and to explain the importance of the establishment's reporting. By describing the use of the published statistics and showing the impact of nonresponse, the USGS strives to encourage respondents to give complete and accurate replies.

The OMB publication "Guidelines for Reducing Reporting Burden" stipulates that the minimum acceptable response rate is 75% of the panel surveyed. In addition, the USGS strives for a minimum reporting level of 75% of the quantity produced or consumed (depending on the survey) for certain key statistics. Response rates are periodically reviewed. For those surveys that do not meet the minimum reporting level, procedures are developed and implemented to improve response rates.

Estimation for Nonresponse.—When efforts to obtain a response to a survey fail, estimation or imputation techniques must be used to account for missing data. Some of the estimation methods depend on knowledge of prior establishment reporting; other techniques rely on external information to estimate the missing data. When survey forms are received after the current publication has been completed, the forms are reviewed, necessary imputations are made for missing data, and the survey database is updated. The revised data are reported in later publications.

Protection of Proprietary Data.—The USGS relies on the cooperation of the U.S. minerals industry to provide the minerals data that are presented in this and other USGS minerals information publications. Without a strong response to survey requests, the USGS would not be able to present reliable statistics. The USGS, in turn, respects the proprietary nature of the data received from the individual companies and establishments. To ensure that proprietary rights will not be violated, the USGS analyzes each of the aggregated statistics to determine if the data reported by an individual establishment can be deduced from the aggregated statistics. If, for example, there are only two significant producers of a mineral commodity in a given State, then the USGS will not publish the State total because either producer could readily estimate the production of the other. It is this obligation to protect proprietary information that results in the withheld entries indicated with the symbol "W" in the published tables. If a company gives permission in writing, however, then the USGS will publish the data as long as the data from other respondents are protected from disclosure.

International Data

International data are collected by USGS country specialists and international data coordinators. The data are gathered from various sources, which include published reports of foreign Government mineral and statistical agencies, international organizations, the U.S. Department of State, the United Nations, the Organization of the Petroleum Exporting Countries, and personal contact by specialists traveling abroad. Each February, minerals questionnaires requesting estimates of mineral production for the country for the preceding year are sent to foreign organizations. Missing data are estimated by USGS country specialists on the basis of historical trends and the specialist's knowledge of current production capabilities in each country.

Publications

The USGS disseminates current and historical minerals information through printed publications and its Web site.

Printed Publications.—The Minerals Yearbook summarizes annually, on a calendar-year basis, the significant economic and technical developments in the mineral industries. Three volumes are issued each year—volume I, Metals and Minerals; volume II, Area Reports: Domestic; and volume III, Area Reports: International. Volume I presents, by mineral commodity, salient statistics on production, trade, consumption, and other measures of economic activity. Volume II reviews the U.S. minerals industry by State and island possessions. Volume III is published as four separate regional reports that cover more than 175 foreign countries; these reports contain individual country chapters that examine the mining, refining, processing, and use of minerals in each country in the region and how they relate to U.S. industry. Volume III chapters also contain information on fuels.

The Mineral Commodity Summaries (MCS), which is an up-to-date summary of more than 90 individual minerals and materials, is the earliest Government publication to furnish estimates that cover the previous year's nonfuel mineral industry data. It contains information on the domestic industry structure, Government programs, tariffs, 5-year salient domestic statistics, and a summary of significant events, trends, and issues in the domestic and international minerals industry during the past year.

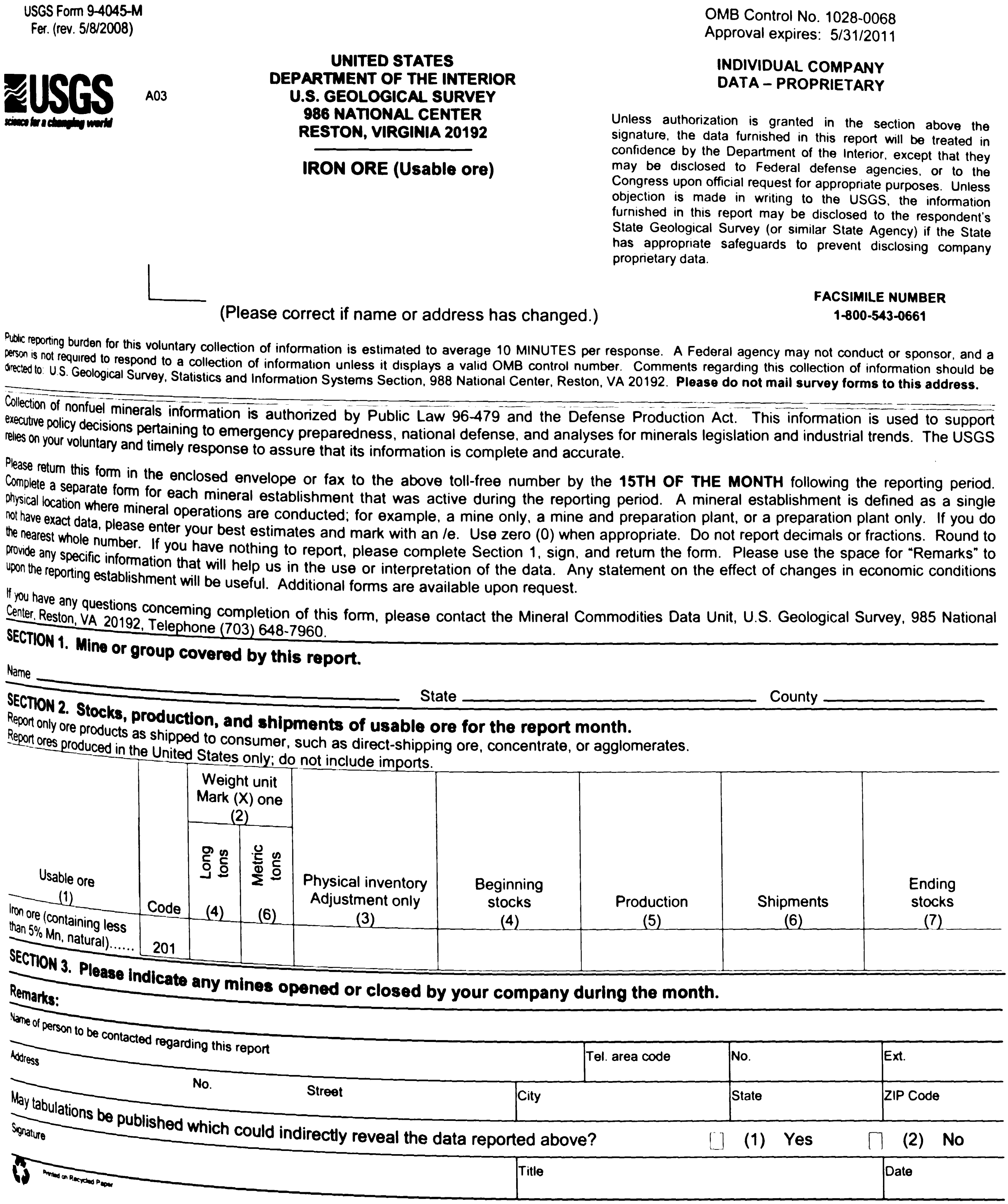
The Minerals Yearbook and the MCS may be purchased by mail from the U.S. Government Printing Office, P.O. Box 979050, St. Louis, MO 63197–9000; telephone, (202) 512–1800 or (866) 512–1800 (toll-free); Internet, http://bookstore.gpo.gov.

Electronic Publications.—Current and historical minerals information is available through the USGS Web site at http://minerals.usgs.gov/minerals/. The Web site provides USGS minerals information products as well as USGS contacts for minerals information and links to other mineral-related sites on the Internet.

Mineral Industry Surveys (MISs) contain timely statistical and economic data on minerals. The surveys are designed to keep government agencies and the public, particularly the mineral industry and the business community, informed of trends in the production, distribution, inventories, and consumption of minerals. Frequency of issue depends on the demand for current data. MISs are released monthly, quarterly, or annually.

The Metal Industry Indicators (MII) report, which is published monthly, contains indexes that measure the current and future performance of three U.S. metal industries. For each of the three industries, a composite coincident index and a composite leading index have been developed based on procedures and data similar to those used to construct The Conference Board's coincident and leading cyclical indexes for the national economy. MIIs also contain several indicators for metal prices. Nonmetallic Mineral Products Industry Indexes, also published monthly, contains leading and coincident indexes that measure the current and future performance of the industrial minerals industry. The indexes were designed by using the same procedures as the USGS metal composite indexes.

FIGURE 1
A TYPICAL SURVEY FORM



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DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
986 NATIONAL CENTER
RESTON, VIRGINIA 20192

IRON ORE (Usable ore)

INDIVIDUAL COMPANY
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Collection of nonfuel minerals information is authorized by Public Law 96-479 and the Defense Production Act. This information is used to support executive policy decisions pertaining to emergency preparedness, national defense, and analyses for minerals legislation and industrial trends. The USGS relies on your voluntary and timely response to assure that its information is complete and accurate.

Please return this form in the enclosed envelope or fax to the above toll-free number by the **15TH OF THE MONTH** following the reporting period. Complete a separate form for each mineral establishment that was active during the reporting period. A mineral establishment is defined as a single physical location where mineral operations are conducted; for example, a mine only, a mine and preparation plant, or a preparation plant only. If you do not have exact data, please enter your best estimates and mark with an /e. Use zero (0) when appropriate. Do not report decimals or fractions. Round to the nearest whole number. If you have nothing to report, please complete Section 1, sign, and return the form. Please use the space for "Remarks" to provide any specific information that will help us in the use or interpretation of the data. Any statement on the effect of changes in economic conditions upon the reporting establishment will be useful. Additional forms are available upon request.

If you have any questions concerning completion of this form, please contact the Mineral Commodities Data Unit, U.S. Geological Survey, 985 National Center, Reston, VA 20192, Telephone (703) 648-7960.

SECTION 1. Mine or group covered by this report.

Name ______________________ State ______________ County ______________

SECTION 2. Stocks, production, and shipments of usable ore for the report month.
Report only ore products as shipped to consumer, such as direct-shipping ore, concentrate, or agglomerates.
Report ores produced in the United States only; do not include imports.

Usable ore (1)	Code	Weight unit Mark (X) one (2)		Physical inventory Adjustment only (3)	Beginning stocks (4)	Production (5)	Shipments (6)	Ending stocks (7)
		Long tons (4)	Metric tons (6)					
Iron ore (containing less than 5% Mn, natural)......	201							

SECTION 3. Please indicate any mines opened or closed by your company during the month.

Remarks:

Name of person to be contacted regarding this report	Tel. area code	No.	Ext.
Address No. Street	City	State	ZIP Code

May tabulations be published which could indirectly reveal the data reported above? ☐ (1) Yes ☐ (2) No

Signature	Title	Date

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STATISTICAL SUMMARY

By Joseph M. Krisanda

The world production table was prepared by Glenn J. Wallace, international data coordinator.

This annual report summarizes data on crude nonfuel mineral production[1] for the United States, its island possessions, and the Commonwealth of Puerto Rico.

Although crude mineral production may be measured at any of several stages of extraction and processing, the stage of measurement used in this annual report is what is termed "mine output." This term refers to minerals or ores in the form in which they are first extracted from the ground, but customarily may include the output from auxiliary processing at or near the mines.

Because of inadequacies in the statistics available, some series deviate from the foregoing definition. For copper, gold, lead, silver, and zinc, the quantities listed are recorded on a mine basis (as the recoverable content of ore sold or treated). The values assigned to the quantities, however, are based on the average selling price of refined metal, not the mine value.

The total value of all nonfuel mineral production in the United States in 2009 decreased to $59.0 billion, which was a 17% decrease compared with that of 2008; metals decreased to $21.9 billion, which was a decrease of 20%; and industrial minerals decreased to $37.1 billion, a decrease of 16%.

In 2009, the value of nonfuel mineral commodity production for the following 12 mined commodities, in descending order of production value, was greater than $1 billion: stone (crushed), gold, sand and gravel (construction), copper, cement (portland), phosphate rock (marketable), molybdenum concentrates, iron ore (usable shipped), salt, lime, soda ash, and zinc. They accounted for 88% of the U.S. total production value (table 1).

In 2009, the value of nonfuel mineral commodity production in the following 17 States, in descending order of production value, was greater than $1 billion: Nevada, Arizona, Florida, Utah, California, Texas, Alaska, Minnesota, Missouri, Wyoming, Michigan, Pennsylvania, Colorado, Georgia, New York, Ohio, and Alabama. They accounted for 73% of the U.S. total production value (table 3).

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[1] The terms "nonfuel mineral production" and related "values" encompass variations in meaning, depending upon the mineral products. Production may be measured by mine shipments, mineral commodity sales, or marketable production (including consumption by producers) as is applicable to the individual mineral commodity.

All 2009 U.S. Geological Survey (USGS) mineral production data published in this chapter are as of July 2011. For some mineral commodities, such as construction sand and gravel, crushed stone, and portland cement, estimates are updated periodically. To obtain the most current information, please contact the appropriate USGS mineral commodity specialist. Specialist contact information is available on the Internet at http://minerals.usgs.gov/minerals/contacts/comdir.html; alternatively, specialists' names and telephone numbers may be obtained by calling USGS information at (703) 648-4000 or by calling the USGS Earth Science Information Center at 1-888-ASK-USGS (275-8747). Minerals Yearbook chapters (for mineral commodities, States, and countries) and Mineral Industry Surveys are also available on the Internet at http://minerals.usgs.gov/minerals.

TABLE 1

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral		2007		2008		2009	
		Quantity	Value	Quantity	Value	Quantity	Value
Metals:							
Beryllium concentrates[4]	metric tons	3,810	NA	4,410	NA	3,030	NA
Cadmium[e, 5]	do.	3,070	23,400	2,990	17,700	2,840	8,140
Copper[6]		1,170	8,450,000	1,310	9,200,000	1,180	6,280,000
Gold[6]	kilograms	238,000	5,350,000	233,000	6,550,000	223,000	7,000,000
Iron ore, usable shipped		50,900	3,040,000	53,600 [r]	3,770,000	27,600	2,560,000
Lead[6]	metric tons	434,000	1,180,000	399,000	1,060,000	395,000	757,000
Molybdenum concentrates[7]	do.	57,000	3,530,000	55,900	3,830,000	47,800	2,870,000
Palladium[6]	kilograms	12,800	148,000	11,900 [r]	136,000	12,700	108,000
Platinum[6]	do.	3,860	162,000	3,580 [r]	182,000	3,830	149,000
Silver[6]	do.	1,280,000	554,000	1,250,000	600,000	1,250,000	588,000
Zinc[6]	metric tons	769,000	2,620,000	748,000	1,470,000	710,000	1,220,000
Combined values of magnesium metal, titanium concentrates, tungsten, zirconium concentrates		XX	308,000 [r]	XX	518,000 [r]	XX	345,000
Total		XX	25,400,000	XX	27,300,000	XX	21,900,000
Industrial minerals, excluding fuels:[8]							
Barite		455	20,600	648	30,900	383	19,900
Cement:[9]							
Masonry		4,320	614,000 [e]	3,030	428,000 [e]	1,970	269,000 [e]
Portland		91,100	9,230,000 [e]	83,300	8,390,000 [e]	62,000	5,960,000 [e]
Clays:							
Ball		1,070	49,000	968	44,300	831	37,700
Bentonite		4,820	252,000	4,910 [r]	267,000 [r]	3,650	207,000
Common		20,600	216,000	17,500	202,000	12,500	156,000
Fire		565	23,800	296 [r]	11,800 [r]	320	12,000
Fuller's earth		2,600	247,000	2,340 [r, 10]	230,000 [r, 10]	2,010 [10]	206,000 [10]
Kaolin		7,110	959,000	6,740	900,000	5,290	714,000
Diatomite		687	163,000	764	171,000	575	147,000
Feldspar[9]		730 [11]	43,800	650 [11]	40,000 [r]	550 [11]	35,600
Garnet, industrial[9]	metric tons	61,400	11,300	62,900	13,600	45,600	6,850
Gemstones, natural[9]		NA	11,900	NA	11,500	NA	8,410
Gypsum, crude[9]		15,700 [r]	95,000 [r]	12,300 [r]	91,200 [r]	10,400	77,400
Helium:							
Crude	million cubic meters	40	68,900	42	90,100	40	85,700
Grade-A	do.	138	497,000	130	630,000	117	572,000
Kyanite		118	29,100	97	25,500	71	20,000
Lime		20,200	1,760,000	19,800	1,830,000	15,800	1,650,000
Mica, crude	metric tons	96,600	14,400	84,000	12,000 [r]	50,100	7,040
Peat		694	17,800	647	17,100	644	15,000
Perlite, crude	metric tons	409,000	18,500	434,000	20,800	348,000	17,100
Phosphate rock, marketable[9]		29,700	1,520,000	30,200	2,320,000	26,400	3,360,000
Potash, gross weight[11]		2,600	480,000	2,400	740,000	1,500	500,000
Pumice and pumicite	metric tons	1,270,000	28,900	791,000	15,900	410,000	12,300
Salt		45,500	1,520,000	47,400 [r]	1,690,000 [r]	43,100	1,750,000
Sand and gravel:							
Construction		1,250,000 [r]	8,820,000 [r]	1,060,000 [r]	7,900,000 [r]	836,000	6,330,000
Industrial		30,100	832,000	30,400	940,000 [r]	24,600	783,000
Silica stone[12]	metric tons	231	1,020	(13)	W	(13)	W
Soda ash[9]		11,100	1,260,000	11,300	1,520,000	9,310	1,330,000

See footnotes at end of table.

TABLE 1—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2007		2008		2009	
	Quantity	Value	Quantity	Value	Quantity	Value
Industrial minerals, excluding fuels—Continued:						
Stone:						
Crushed[14]	1,650,000	14,100,000	1,460,000[r]	13,600,000[r]	1,170,000	11,300,000
Dimension	1,920	346,000	1,800	326,000[r]	1,620	328,000
Talc, crude[9]	769	24,400	706	21,800	511	14,600
Tripoli[9] metric tons	96,400	17,400	132,000	17,100	79,700	16,400
Vermiculite, concentrate[e]	100[15]	W	100[15]	W	100[15]	W
Combined values of andalusite, boron minerals, bromine, brucite (2007–08), clays [fuller's earth (2008–09)], emery (2008–09), greensand marl, iodine (crude), iron oxide pigments (crude), lithium carbonate, magnesite, magnesium compounds, olivine, pyrophyllite (crude), staurolite, wollastonite, zeolites, and values indicated by symbol W	XX	1,340,000[r]	XX	1,380,000	XX	1,120,000
Total	XX	44,700,000[r]	XX	44,000,000[r]	XX	37,100,000
Grand total	XX	70,000,000	XX	71,300,000[r]	XX	59,000,000

[e] Estimated. [r] Revised. do. Ditto. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined values." XX Not applicable.

[1] Table includes data available through July 26, 2011.

[2] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[3] Data are rounded to no more than three significant digits; may not add to totals shown.

[4] Shipments.

[5] Byproduct from zinc concentrates.

[6] Recoverable content of ores, etc.

[7] Content of ore and concentrate.

[8] Sold or used unless otherwise specified.

[9] Production.

[10] Excludes attapulgite; included in "Combined values."

[11] Data are rounded to two significant digits.

[12] Includes grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.

[13] Withheld to avoid disclosing company proprietary data.

[14] Excludes abrasive stone and bituminous limestone and sandstone; all included elsewhere in table.

[15] Data are rounded to one significant digit.

TABLE 2

NONFUEL MINERALS PRODUCED IN THE UNITED STATES, BY COMMODITY AND STATES IN 2009[1]

(Principal States based on quantity unless otherwise noted)

Mineral	Principal States	Other States (alphabetical order)
Andalusite	NC	
Barite	NV and GA	
Beryllium concentrates	UT	
Boron	CA	
Bromine	AR	
Cement:		
Masonry	CA, IN, AL, TX, PA	AR, AZ, CO, FL, GA, IA, KS, KY, MD, ME, MI, MO, NE, NM, NY, OH, OK, SC, TN, VA, WV.
Portland	TX, CA, MO, PA, MI	All other States, except AK, CT, DE, HI, LA, MA, MN, NC, ND, NH, NJ, RI, VT, WI.
Clays:		
Ball	TN, TX, MS, KY, IN	
Bentonite	WY, MT, UT, AL, TX	AZ, CA, CO, MS, NV, OR.
Common	TX, AL, NC, OH, GA	All other States, except AK, DE, HI, ID, MN, NH, NJ, NV, OR, RI, VT, WI.
Fire	MO, CA, OH, TX, WA	CO.
Fuller's earth	GA, MO, MS, VA, CA	FL, IL, KS, NV, TN, TX.
Kaolin	GA, SC, AL, AR, NV	CA, FL, NC, TX.
Copper[2]	AZ, UT, NV, NM, MT	ID and MO.
Diatomite	CA, NV, OR, WA	
Emery	OR	
Feldspar	NC, VA, CA, ID, OK	GA and SD.
Garnet, industrial	MT, NY, ID	
Gemstones, natural[3]	AZ, OR, UT, CA, ID	All other States.
Gold[2]	NV, AK, UT, CO, WA	AZ, CA, ID, MT, NM, SD.
Greensand marl	NJ	
Gypsum, crude	OK, IA, TX, IN, NV	AR, AZ, CA, CO, KS, LA, MI, NM, SD, UT, WY.
Helium:		
Crude	KS and TX	
Grade-A	KS, WY, TX, OH, OK	CO, NM, UT.
Iodine, crude	OK	
Iron ore, usable	MN, MI, SD, CA	
Iron oxide pigments, crude	GA, AL, VA	
Kyanite	VA	
Lead[2]	AK, MO, ID, MT, WA	
Lime	MO, AL, KY, OH, NV	All other States, except AK, CT, DE, HI, IL, KS, MD, ME, MS, NC, NH, NJ, NM, NY, RI, SC, VT.
Lithium carbonate	NV	
Magnesite	NV	
Magnesium compounds	MI, UT, FL, DE, CA	
Magnesium metal	UT	
Mica, crude	SD, NC, GA, AL	
Molybdenum, concentrates	CO, AZ, UT, ID, MT	NM and NV.
Olivine	WA and NC	
Palladium[2]	MT	
Peat	FL, MN, IL, ME, NY	IA, IN, MI, NJ, OH, PA, WA
Perlite, crude	NM, OR, AZ, ID, CA	NV.
Phosphate rock	FL, NC, ID, UT	
Platinum[2]	MT	
Potash	NM, UT, MI	
Pumice and pumicite	CA, OR, NM, ID, NV	AZ and KS.
Pyrophyllite, crude	NC and CA	
Salt	LA, TX, NY, OH, KS	AL, AZ, CA, MI, NM, NV, OK, TN, UT, VA, WV.

See footnotes at end of table.

TABLE 2—Continued

NONFUEL MINERALS PRODUCED IN THE UNITED STATES, BY COMMODITY AND STATES IN 2009[1]

(Principal States based upon quantity unless otherwise noted)

Mineral	Principal States	Other States (alphabetical order)
Sand and gravel:		
Construction	CA, TX, AZ, MI, UT	All other States.
Industrial	IL, WI, TX, OK, MN	All other States, except AK, CT, DE, HI, KY, MA, MD, ME, MT, NH, NM, OR, SD, UT, VT, WY.
Silica stone[4]	AR	
Silver[2]	AK, NV, ID, UT, AZ	CA, CO, MO, MT, NM, SD.
Soda ash	WY and CA	
Staurolite	FL	
Stone:		
Crushed	TX, PA, MO, IL, FL	All other States.
Dimension	TX, WI, IN, GA, VT	All other States, except AK, DE, FL, HI, IA, KY, LA, MS, ND, NE, NJ, OR, RI.
Talc, crude	MT, TX, VT	
Titanium concentrates, ilmenite	VA and FL	
Tripoli	IL, OK, AR, PA	
Tungsten	CA	
Vermiculite, crude	SC and VA	
Wollastonite	NY	
Zeolites	NM, ID, TX, AZ, CA	NV.
Zinc[2]	AK, MO, ID, WA, MT	TN.
Zirconium concentrates	FL and VA	

[1] Table includes data available through July 26, 2011.

[2] Content of ores, etc.

[3] Principal States based on value.

[4] Grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.

TABLE 3

VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2009[1, 2]

State	Value (thousands)	Rank	Percentage of U.S. total	Principal minerals, in order of value
Alabama	$1,020,000	17	1.73	Stone (crushed), cement (portland), lime, sand and gravel (construction), cement (masonry).
Alaska	2,620,000	7	4.45	Zinc, gold, lead, silver, sand and gravel (construction).
Arizona	5,180,000	2	8.79	Copper, molybdenum concentrates, sand and gravel (construction), cement (portland), stone (crushed).
Arkansas	636,000	30	1.08	Stone (crushed), bromine, cement (portland), sand and gravel (construction), lime.
California	3,070,000	5	5.20	Sand and gravel (construction), cement (portland), boron minerals, stone (crushed), gold.
Colorado	1,420,000	13	2.40	Molybdenum concentrates, sand and gravel (construction), gold, cement (portland), stone (crushed).
Connecticut[3]	162,000	43	0.27	Stone (crushed), sand and gravel (construction), clays (common), stone (dimension), gemstones (natural).
Delaware[3]	24,500	50	0.04	Magnesium compounds, sand and gravel (construction), stone (crushed), gemstones (natural).
Florida	4,250,000	3	7.20	Phosphate rock, stone (crushed), cement (portland), sand and gravel (construction), zirconium concentrates.
Georgia	1,410,000	14	2.39	Clays (kaolin), stone (crushed), clays (fuller's earth), cement (portland), sand and gravel (construction).
Hawaii	116,000	46	0.20	Stone (crushed), sand and gravel (construction), gemstones (natural).
Idaho	935,000	21	1.59	Molybdenum concentrates, phosphate rock, silver, sand and gravel (construction), lead.
Illinois	929,000	22	1.57	Stone (crushed), sand and gravel (construction), cement (portland), sand and gravel (industrial), tripoli.
Indiana	806,000	25	1.37	Stone (crushed), cement (portland), sand and gravel (construction), lime, stone (dimension).
Iowa	596,000	31	1.01	Stone (crushed), cement (portland), sand and gravel (construction), lime, gypsum (crude).
Kansas	953,000	20	1.62	Helium (Grade–A), salt, cement (portland), stone (crushed), helium (crude).
Kentucky	668,000	27	1.13	Stone (crushed), lime, cement (portland), sand and gravel (construction), clays (common).
Louisiana	568,000	32	0.96	Salt, sand and gravel (construction), stone (crushed), sand and gravel (industrial), clays (common).
Maine	125,000	44	0.21	Sand and gravel (construction), stone (crushed), cement (portland), stone (dimension), peat.
Maryland	497,000	34	0.84	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry), stone (dimension).
Massachusetts[3]	214,000	41	0.36	Stone (crushed), sand and gravel (construction), lime, stone (dimension), clays (common).
Michigan	1,760,000	11	2.99	Iron ore (usable shipped), cement (portland), sand and gravel (construction), salt, stone (crushed).
Minnesota	2,150,000	8	3.65	Iron ore (usable shipped), sand and gravel (construction), stone (crushed), sand and gravel (industrial), stone (dimension).
Mississippi	208,000	42	0.35	Sand and gravel (construction), stone (crushed), clays (fuller's earth), clays (ball), cement (portland).
Missouri	1,810,000	9	3.07	Stone (crushed), cement (portland), lead, lime, sand and gravel (construction).
Montana	982,000	18	1.67	Molybdenum concentrates, copper, platinum metal, palladium metal, sand and gravel (construction).
Nebraska	248,000	38	0.42	Cement (portland), sand and gravel (construction), stone (crushed), sand and gravel (industrial), lime.
Nevada	6,020,000	1	10.21	Gold, copper, sand and gravel (construction), lime, silver.
New Hampshire	108,000	47	0.18	Sand and gravel (construction), stone (crushed), stone (dimension), gemstones (natural).
New Jersey[3]	270,000	37	0.46	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), greensand marl, peat.
New Mexico	886,000	23	1.50	Potash, copper, sand and gravel (construction), stone (crushed), cement (portland).
New York	1,370,000	15	2.32	Salt, stone (crushed), sand and gravel (construction), cement (portland), clays (common).
North Carolina	846,000	24	1.44	Stone (crushed), phosphate rock, sand and gravel (construction), sand and gravel (industrial), stone (dimension).
North Dakota[3]	51,000	48	0.09	Sand and gravel (construction), lime, stone (crushed), clays (common), sand and gravel (industrial).
Ohio	1,130,000	16	1.92	Stone (crushed), salt, sand and gravel (construction), lime, cement (portland).
Oklahoma	667,000	28	1.13	Stone (crushed), cement (portland), sand and gravel (construction), iodine, sand and gravel (industrial).
Oregon	314,000	36	0.53	Stone (crushed), sand and gravel (construction), cement (portland), diatomite, perlite (crude).
Pennsylvania[3]	1,620,000	12	2.75	Stone (crushed), cement (portland), lime, sand and gravel (construction), cement (masonry).
Rhode Island[3]	43,400	49	0.07	Sand and gravel (construction), stone (crushed), sand and gravel (industrial), gemstones (natural).
South Carolina[3]	449,000	35	0.76	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry), sand and gravel (industrial).
South Dakota	230,000	39	0.39	Gold, cement (portland), sand and gravel (construction), stone (crushed), stone (dimension).
Tennessee	675,000	26	1.14	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial), lime.
Texas	2,650,000	6	4.49	Cement (portland), stone (crushed), sand and gravel (construction), salt, lime.
Utah	3,900,000	4	6.62	Copper, molybdenum concentrates, gold, magnesium metal, sand and gravel (construction).
Vermont[3]	122,000	45	0.21	Stone (crushed), sand and gravel (construction), stone (dimension), talc (crude), gemstones (natural).

See footnotes at end of table.

TABLE 3—Continued

VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2009[1, 2]

State	Value (thousands)	Rank	Percentage of U.S. total	Principal minerals, in order of value
Virginia	$955,000	19	1.62	Stone (crushed), sand and gravel (construction), cement (portland), lime, zirconium (concentrates).
Washington	650,000	29	1.10	Sand and gravel (construction), gold, stone (crushed), cement (portland), lime.
West Virginia	215,000	40	0.37	Stone (crushed), cement (portland), lime, sand and gravel (industrial), cement (masonry).
Wisconsin	546,000	33	0.93	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), lime, stone (dimension).
Wyoming	1,800,000	10	3.05	Soda ash, helium (Grade–A), clays (bentonite), sand and gravel (construction), stone (crushed).
Undistributed	89,500	XX	0.15	
Total	59,000,000	XX	100.00	

XX Not applicable.

[1] Table includes data available through July 26, 2011.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Partial total; excludes values that must be withheld to avoid disclosing company proprietary data which are included with "Undistributed."

TABLE 4

VALUE OF NONFUEL MINERAL PRODUCTION PER CAPITA AND PER SQUARE KILOMETER IN 2009 BY STATE[1, 2]

State	Land area (square kilometers)	Population (thousands)	Total value (thousands)	Per capita Dollars	Per capita Rank	Per square kilometer Dollars	Per square kilometer Rank
Alabama	131,000	4,710	$1,020,000	$216	16	$7,750	19
Alaska	1,480,000	698	2,620,000	3,750	1	1,770	44
Arizona	294,000	6,600	5,180,000	785	6	17,600	5
Arkansas	135,000	2,890	636,000	220	15	4,720	32
California	404,000	37,000	3,070,000	83	39	7,590	20
Colorado	269,000	5,030	1,420,000	282	13	5,270	28
Connecticut	12,500	3,520	162,000 [3]	46	46	12,900	9
Delaware	5,060	885	24,500 [3]	28	50	4,840	31
Florida	140,000	18,500	4,250,000	229	14	30,400	1
Georgia	150,000	9,830	1,410,000	144	22	9,420	16
Hawaii	16,600	1,300	116,000	89	37	6,950	22
Idaho	214,000	1,550	935,000	605	7	4,360	35
Illinois	144,000	12,900	929,000	72	43	6,450	25
Indiana	92,900	6,420	806,000	125	26	8,670	18
Iowa	145,000	3,010	596,000	198	17	4,120	36
Kansas	212,000	2,820	953,000	338	10	4,500	34
Kentucky	103,000	4,310	668,000	155	21	6,490	24
Louisiana	113,000	4,490	568,000	126	25	5,030	30
Maine	79,900	1,320	125,000	95	35	1,570	46
Maryland	25,300	5,700	497,000	87	38	19,600	3
Massachusetts	20,300	6,590	214,000 [3]	32	48	10,500	13
Michigan	147,000	9,970	1,760,000	177	20	12,000	10
Minnesota	206,000	5,270	2,150,000	408	9	10,400	14
Mississippi	121,000	2,950	208,000	70	44	1,710	45
Missouri	178,000	5,990	1,810,000	302	11	10,100	15
Montana	377,000	975	982,000	1,010	5	2,610	43
Nebraska	199,000	1,800	248,000	138	23	1,250	48
Nevada	284,000	2,640	6,020,000	2,280	3	21,200	2
New Hampshire	23,200	1,330	108,000	81	41	4,630	33
New Jersey	19,200	8,710	270,000 [3]	31	49	14,100	7
New Mexico	314,000	2,010	886,000	441	8	2,820	42
New York	122,000	19,500	1,370,000	70	45	11,200	11
North Carolina	126,000	9,380	846,000	90	36	6,710	23
North Dakota	179,000	647	51,000 [3]	79	42	285	50
Ohio	106,000	11,500	1,130,000	98	32	10,700	12
Oklahoma	178,000	3,690	667,000	181	19	3,750	40
Oregon	249,000	3,830	314,000	82	40	1,260	47
Pennsylvania	116,000	12,600	1,620,000 [3]	129	24	14,000	8
Rhode Island	2,710	1,050	43,400 [3]	41	47	16,100	6
South Carolina	78,000	4,560	449,000 [3]	98	31	5,760	27
South Dakota	197,000	812	230,000	283	12	1,170	49
Tennessee	107,000	6,300	675,000	107	29	6,320	26
Texas	678,000	24,800	2,650,000	107	30	3,910	37
Utah	213,000	2,790	3,900,000	1,400	4	18,400	4
Vermont	24,000	622	122,000 [3]	196	18	5,080	29
Virginia	103,000	7,880	955,000	121	27	9,320	17
Washington	172,000	6,660	650,000	97	33	3,770	39
West Virginia	62,400	1,820	215,000	118	28	3,460	41
Wisconsin	141,000	5,660	546,000	97	34	3,880	38
Wyoming	251,000	544	1,800,000	3,310	2	7,160	21
Undistributed	XX	XX	89,500	XX	XX	XX	XX
Total or average	9,160,000 [4]	306,000 [4]	59,000,000	192	XX	6,440	XX

See footnotes at end of table.

TABLE 4—Continued

VALUE OF NONFUEL MINERAL PRODUCTION PER CAPITA AND PER SQUARE KILOMETER IN 2009 BY STATE[1, 2]

XX Not applicable.

[1] Table includes data available through July 26, 2011.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Partial total; excludes values that must be concealed to avoid disclosing company proprietary data. Concealed values included with "Undistributed."

[4] Excludes Washington, DC (which has no mineral production), with an area of 179 square kilometers and a population of 600,000.

Sources: U.S. Geological Survey and U.S. Census Bureau.

TABLE 5

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2007		2008		2009	
	Quantity	Value	Quantity	Value	Quantity	Value
Alabama:						
Cement:						
Masonry	450	59,300 [e]	303	38,000 [e]	208	25,600 [e]
Portland	5,060	486,000 [e]	4,640	450,000 [e]	3,420	307,000 [e]
Clays, common	2,240	42,300	1,970	34,400	1,340	25,300
Gemstones, natural	NA	398	NA	398	NA	143
Lime	2,480	234,000	2,320	239,000	1,960	225,000
Sand and gravel:						
Construction	16,700	96,500	13,800 [r]	87,300 [r]	10,000	64,800
Industrial	459	9,810	619	14,600	370	11,200
Stone:						
Crushed	55,600	382,000	50,000	370,000 [r]	36,400	332,000
Dimension, marble, sandstone	(4)	W	7	3,720	4	1,460
Combined values of clays (bentonite, kaolin), iron oxide pigments (crude), mica [crude (2008–09)], salt, and value indicated by symbol W	XX	24,300	XX	26,700 [r]	XX	26,500
Total	XX	1,330,000	XX	1,260,000 [r]	XX	1,020,000
Alaska:						
Gemstones, natural	NA	13	NA	69	NA	69
Sand and gravel, construction	13,400 [r]	78,000 [r]	11,400 [r]	84,800 [r]	7,320	55,500
Stone, crushed	1,750	20,000	1,990 [r]	31,400 [r]	1,940	34,800
Combined values of cadmium (byproduct from zinc concentrates), gold, lead, silver, zinc	XX	3,440,000	XX	2,540,000	XX	2,530,000
Total	XX	3,540,000	XX	2,650,000 [r]	XX	2,620,000
Arizona:						
Clays, bentonite	30	1,520	23	1,220	17	913
Copper[5]	731	5,290,000	836	5,880,000	711	3,780,000
Gemstones, natural	NA	1,950	NA	1,960	NA	1,540
Gypsum, crude	292	1,770	247	1,840	213	1,740
Sand and gravel, construction	86,500 [r]	657,000 [r]	67,200 [r]	562,000 [r]	40,200	357,000
Stone:						
Crushed	17,100	157,000	15,300 [r]	153,000 [r]	9,120	80,000
Dimension, sandstone	(4)	W	123	16,400	94	13,800
Combined values of cement, clays (common), gold, lime, molybdenum concentrates, perlite (crude), pumice and pumicite, salt, sand and gravel (industrial), silver, zeolites, and value indicated by symbol W	XX	1,170,000 [r]	XX	1,230,000 [r]	XX	942,000
Total	XX	7,280,000	XX	7,850,000 [r]	XX	5,180,000
Arkansas:						
Clays, common	1,120	4,520	796	10,700	539	7,630
Gemstones, natural	NA	601	NA	607	NA	410
Sand and gravel, construction	9,080	66,300	8,800	65,100	8,980	69,800
Silica stone[6] metric tons	231	1,020	(4)	W	(4)	W
Stone:						
Crushed	33,000	237,000	32,200	241,000 [r]	30,000	217,000
Dimension	(4)	W	21	2,740	18	2,360
Combined values of bromine, cement, clays (kaolin), gypsum (crude), lime, sand and gravel (industrial), tripoli, and values indicated by symbol W	XX	467,000 [r]	XX	390,000 [r]	XX	339,000
Total	XX	776,000 [r]	XX	710,000 [r]	XX	636,000

See footnotes at end of table.

TABLE 5—Continued
NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2007		2008		2009	
	Quantity	Value	Quantity	Value	Quantity	Value
California:						
Cement:						
Masonry	522	68,900 ^{e}	337	43,600 ^{e}	236	28,100 ^{e}
Portland	10,800	1,180,000 ^{e}	9,880	1,030,000 ^{e}	7,150	646,000 ^{e}
Clays:						
Bentonite	29	3,090	30	3,360	22	2,310
Common	549	3,390	469	3,570	318	2,370
Fire	(4)	W	118	W	(4)	W
Gemstones, natural	NA	818	NA	732	NA	727
Gypsum, crude	1,150	6,980	861	6,390	825	5,850
Sand and gravel:						
Construction	142,000 ^{r}	1,530,000 ^{r}	111,000 ^{r}	1,260,000 ^{r}	79,200	912,000
Industrial	1,850	43,400	1,500	42,300	1,300	35,800
Stone:						
Crushed	51,000	533,000	51,400 ^{r}	572,000 ^{r}	41,400	378,000
Dimension	39	12,300	26	7,320	25	6,100
Combined values of boron minerals, clays (fuller's earth, kaolin), diatomite, feldspar, gold, iron ore (usable shipped), lime, magnesium compounds, perlite (crude), pumice and pumicite, pyrophyllite (2009), salt, silver, soda ash, talc [crude (2007–08)], tungsten, zeolites, and values indicated by symbol W	XX	1,030,000 ^{r}	XX	1,240,000 ^{r}	XX	1,050,000
Total	XX	4,420,000	XX	4,200,000	XX	3,070,000
Colorado:						
Clays:						
Bentonite	(4)	W	2	40	1	30
Common	174	1,100	141	644	60	405
Gemstones, natural	NA	261	NA	419	NA	426
Sand and gravel, construction	47,200 ^{r}	373,000 ^{r}	37,800 ^{r}	299,000 ^{r}	29,300	217,000
Stone:						
Crushed	10,300	76,700	9,590 ^{r}	71,300 ^{r}	6,970	63,200
Dimension	21	3,870	27	4,510	11	3,110
Combined values of cement, clays [fire (2009)], gold, gypsum (crude), helium (Grade–A), lime, molybdenum concentrates, sand and gravel (industrial), silver, and value indicated by symbol W	XX	1,590,000	XX	1,680,000	XX	1,130,000
Total	XX	2,050,000 ^{r}	XX	2,060,000 ^{r}	XX	1,420,000
Connecticut:						
Clays, common	36	(7)	(4)	(7)	20	224
Gemstones, natural	NA	6	NA	7	NA	7
Sand and gravel, construction	8,340 ^{r}	73,800 ^{r}	7,350 ^{r}	69,600 ^{r}	5,680	60,800
Stone:						
Crushed	10,400	119,000	9,640 ^{r}	106,000 ^{r}	8,030	101,000
Dimension	(4)	(7)	(4)	(7)	(4)	(7)
Total	XX	192,000	XX	175,000 ^{r}	XX	162,000
Delaware:						
Gemstones, natural	NA	1	NA	1	NA	1
Magnesium compounds	(4)	(7)	(4)	(7)	(4)	(7)
Sand and gravel, construction	3,520	26,400	2,550	20,600	2,080	24,500
Stone, crushed	(4)	(7)	(4)	(7)	(4)	(7)
Total	XX	26,400	XX	20,600	XX	24,500

See footnotes at end of table.

TABLE 5—Continued
NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

	2007		2008		2009	
Mineral	Quantity	Value	Quantity	Value	Quantity	Value
Florida:						
Cement:						
Masonry	524	86,100 [e]	310	47,000 [e]	123	18,700 [e]
Portland	5,510	557,000 [e]	4,980	518,000 [e]	3,150	307,000 [e]
Clays:						
Common	3	W	2	W	(4)	W
Kaolin	21	2,770	19	2,520	18	3,000
Gemstones, natural	NA	1	NA	1	NA	1
Peat	501	9,800	488	9,760	527	10,100
Sand and gravel:						
Construction	30,400 [r]	232,000 [r]	28,200 [r]	219,000	15,600	125,000
Industrial	441	8,110	573	7,480	431	8,270
Stone, crushed	96,400	1,150,000	68,400 [r]	894,000 [r]	48,600	643,000
Combined values of clays (fuller's earth), lime, magnesium compounds, phosphate rock, staurolite, titanium concentrates, zirconium concentrates, and values indicated by symbol W	XX	1,360,000	XX	2,040,000	XX	3,130,000
Total	XX	3,410,000	XX	3,730,000	XX	4,250,000
Georgia:						
Barite	(4)	W	7	1,350	7	1,350
Clays:						
Common	1,350	8,110	952	6,020	631	3,870
Fuller's earth	758	67,700	646 [r, 8]	51,800 [r, 8]	(4)	W
Kaolin	6,570	924,000	6,290	872,000	4,970	693,000
Gemstones, natural	NA	9	NA	74	NA	74
Sand and gravel:						
Construction	10,200	63,800	7,360 [r]	40,300 [r]	5,260	31,100
Industrial	1,040	18,100	841	20,700	775	19,300
Stone:						
Crushed	80,100	815,000	61,900	666,000	45,100	518,000
Dimension	162	18,900	169	18,200	153	16,900
Combined values of cement, clays [fuller's earth (2008)], feldspar, iron oxide pigments (crude), lime, mica (crude), and values indicated by symbol W	XX	148,000	XX	114,000	XX	128,000
Total	XX	2,060,000	XX	1,790,000 [r]	XX	1,410,000
Hawaii:						
Gemstones, natural	NA	151	NA	151	NA	151
Sand and gravel, construction	1,850 [r]	24,100 [r]	1,640 [r]	29,800 [r]	1,130	14,300
Stone, crushed	8,800	141,000	7,410 [r]	134,000 [r]	5,920	101,000
Total	XX	165,000 [r]	XX	164,000 [r]	XX	116,000
Idaho:						
Gemstones, natural	NA	339	NA	430	NA	491
Sand and gravel, construction	24,200 [r]	127,000 [r]	18,800 [r]	107,000 [r]	12,900	75,000
Stone:						
Crushed	6,170	37,500	5,950 [r]	38,800 [r]	4,410	30,800
Dimension, quartzite, sandstone	34	4,200	34	4,130	25	3,370

See footnotes at end of table.

TABLE 5—Continued
NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE$^{1, 2, 3}$

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2007 Quantity	2007 Value	2008 Quantity	2008 Value	2009 Quantity	2009 Value
Idaho—Continued:						
Combined values of cadmium (byproduct from zinc concentrates), cement (portland), copper, feldspar, garnet (industrial), gold, lead, lime, molybdenum concentrates, perlite (crude), phosphate rock, pumice and pumicite, sand and gravel (industrial), silver, zeolites, zinc	XX	612,000	XX	921,000	XX	826,000
Total	XX	781,000 ^{r}	XX	1,070,000	XX	935,000
Illinois:						
Cement, portland	3,120	309,000 ^{e}	2,660	263,000 ^{e}	1,490	141,000 ^{e}
Clays, fuller's earth	(4)	W	112	W	(4)	W
Gemstones, natural	NA	34	NA	10	NA	9
Sand and gravel:						
Construction	32,100 ^{r}	177,000 ^{r}	27,000 ^{r}	168,000 ^{r}	22,500	144,000
Industrial	4,090	86,800	3,980	108,000	3,440	104,000
Stone, crushed	78,400	614,000	67,600 ^{r}	613,000 ^{r}	56,500	513,000
Combined values of clays (common), lime (2007–08), peat, stone, (dimension dolomite), tripoli, and values indicated by symbol W	XX	61,100	XX	60,900	XX	26,900
Total	XX	1,250,000	XX	1,210,000 ^{r}	XX	929,000
Indiana:						
Cement, portland	2,980	263,000 ^{e}	2,590	226,000 ^{e}	2,690	233,000 ^{e}
Clays, common	624	8,980	667	8,080	413	6,610
Gemstones, natural	NA	4	NA	4	NA	4
Sand and gravel, construction	28,300	154,000 ^{r}	23,300 ^{r}	139,000 ^{r}	18,800	100,000
Stone:						
Crushed	57,800	383,000	51,800 ^{r}	352,000 ^{r}	44,100	290,000
Dimension	236	37,800	203	35,600	206	41,500
Combined values of cement (masonry), clays (ball), gypsum (crude), lime, peat, sand and gravel (industrial)	XX	140,000 ^{r}	XX	131,000 ^{r}	XX	134,000
Total	XX	986,000 ^{r}	XX	892,000 ^{r}	XX	806,000
Iowa:						
Clays, common	331	2,630	269	1,140	184	828
Gemstones, natural	NA	3	NA	3	NA	3
Gypsum, crude	1,490	9,050	1,250	9,230	1,780	14,800
Sand and gravel, construction	17,100	94,100 ^{r}	15,800 ^{r}	89,500 ^{r}	13,600	87,600
Stone, crushed	35,500	286,000	38,700 ^{r}	312,000 ^{r}	32,600	297,000
Combined values of cement, lime, peat, sand and gravel (industrial)	XX	289,000 ^{r}	XX	268,000 ^{r}	XX	196,000
Total	XX	681,000 ^{r}	XX	680,000	XX	596,000
Kansas:						
Cement, portland	2,760	282,000 ^{e}	2,400	246,000 ^{e}	1,670	170,000 ^{e}
Clays, common	563	3,830	548	2,840	381	2,430
Gemstones, natural	NA	1	NA	1	NA	1
Helium, Grade-A million cubic meters	88	316,000	79	384,000	68	332,000
Salt	2,870	158,000	3,010	178,000	2,710	188,000
Sand and gravel, construction	11,200 ^{r}	52,100 ^{r}	10,500 ^{r}	51,600 ^{r}	8,580	43,300
Stone:						
Crushed	23,400	199,000	23,100 ^{r}	180,000	17,200	143,000
Dimension	14	1,990	20	2,560	29	4,650

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2007		2008		2009	
	Quantity	Value	Quantity	Value	Quantity	Value
Kansas—Continued:						
Combined values of cement (masonry), clays (fuller's earth), gypsum (crude), helium (crude), pumice and pumicite, sand and gravel (industrial)	XX	62,200 [r]	XX	77,500 [r]	XX	69,200
Total	XX	1,070,000 [r]	XX	1,120,000	XX	953,000
Kentucky:						
Clays, common	598	3,720	419	8,170	288	5,980
Gemstones, natural	NA	48	NA	173	NA	37
Sand and gravel, construction	9,070	48,300	7,620 [r]	41,700 [r]	7,260	39,800
Stone, crushed	56,000	432,000	52,700 [r]	422,000 [r]	44,300	389,000
Combined values of cement, clays (ball), lime	XX	307,000	XX	324,000 [r]	XX	233,000
Total	XX	791,000	XX	796,000 [r]	XX	668,000
Louisiana:						
Clays, common	552	13,800	509	12,900	353	9,120
Gemstones, natural	NA	7	NA	7	NA	7
Salt	13,900	180,000	14,600	231,000	13,200	229,000
Sand and gravel:						
Construction	26,200 [r]	240,000 [r]	22,900 [r]	231,000 [r]	20,600	205,000
Industrial	635	21,200	748	23,100	682	25,900
Combined values of gypsum (crude), lime, stone (crushed limestone and sandstone)	XX	106,000 [r]	XX	123,000 [r]	XX	99,500
Total	XX	561,000 [r]	XX	620,000 [r]	XX	568,000
Maine:						
Gemstones, natural	NA	277	NA	282	NA	352
Sand and gravel, construction	11,300 [r]	85,900 [r]	10,200 [r]	69,100 [r]	9,090	59,300
Stone:						
Crushed	4,680	37,700	4,020 [r]	33,900 [r]	3,600	31,600
Dimension	6	1,580	7	1,720	6	1,300
Combined values of cement, clays (common), peat	XX	53,900	XX	56,000	XX	32,600
Total	XX	179,000 [r]	XX	161,000 [r]	XX	125,000
Maryland:						
Cement, portland	3,000	265,000 [e]	(4)	W	(4)	W
Clays, common	173	W	(4)	W	(4)	W
Gemstones, natural	NA	1	NA	1	NA	1
Sand and gravel:						
Construction	12,400	123,000	12,000	126,000	7,980	99,200
Industrial	--	--	(4)	W	--	--
Stone:						
Crushed	31,100	282,000	26,100 [r]	237,000 [r]	22,300	200,000
Dimension	17	2,680	(4)	W	(4)	W
Combined values of cement (masonry), and values indicated by symbol W	XX	(7)	XX	279,000	XX	198,000
Total	XX	672,000	XX	642,000 [r]	XX	497,000
Massachusetts:						
Clays, common	31	(7)	24	(7)	(4)	(7)
Gemstones, natural	NA	1	NA	1	NA	1
Lime	(4)	(7)	(4)	(7)	(4)	(7)
Sand and gravel, construction	15,800	141,000	11,300 [r]	110,000 [r]	9,460	85,600

See footnotes at end of table.

TABLE 5—Continued
NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2007		2008		2009	
	Quantity	Value	Quantity	Value	Quantity	Value
Massachusetts—Continued:						
Stone:						
Crushed	12,300	140,000	11,200 r	130,000 r	10,500	122,000
Dimension	98	12,000	53	7,140	44	6,130
Total	XX	293,000	XX	246,000 r	XX	214,000
Michigan:						
Cement:						
Masonry	149	20,200 e	99	12,000 e	80	9,800 e
Portland	5,490	537,000 e	4,930	502,000 e	3,550	350,000 e
Clays, common	533	2,250	365	1,730	318	1,310
Gemstones, natural	NA	2	NA	2	NA	2
Gypsum, crude	841 r	5,100 r	603 r	4,490 r	372	3,110
Iron ore, usable shipped	12,200	W	12,500 r	W	8,870	W
Sand and gravel:						
Construction	57,100 r	231,000 r	45,100 r	211,000 r	34,600	176,000
Industrial	1,360	30,000	1,500	26,800	1,330	27,700
Stone, crushed	26,800	130,000	26,100 r	136,000 r	20,400	115,000
Combined values of lime, magnesium compounds, peat, potash, salt, stone (dimension dolomite sandstone), and values indicated by symbol W	XX	1,010,000	XX	1,130,000	XX	1,080,000
Total	XX	1,970,000	XX	2,020,000 r	XX	1,760,000
Minnesota:						
Gemstones, natural	NA	6	NA	7	NA	7
Iron ore, usable shipped	38,800	W	41,100	W	18,700	W
Peat	41	4,350	48	4,540	44	2,850
Sand and gravel, construction	47,000 r	242,000 r	34,700 r	227,000 r	30,800	188,000
Stone:						
Crushed	10,400	111,000	10,300 r	122,000 r	8,670	110,000
Dimension	28	14,400	31	17,200	25	16,700
Combined values of clays [common (2007–08)], lime, sand and gravel (industrial), and values indicated by symbol W	XX	2,410,000	XX	3,090,000	XX	1,830,000
Total	XX	2,790,000 r	XX	3,460,000 r	XX	2,150,000
Mississippi:						
Clays:						
Bentonite	67	4,610	53	3,690	(4)	W
Common	508	2,980	433	2,340	263	1,540
Fuller's earth	(4)	W	384	W	(4)	W
Gemstones, natural	NA	1	NA	1	NA	1
Sand and gravel, construction	15,000	102,000	12,800 r	91,400 r	12,700	101,000
Stone, crushed	3,120	58,900	4,380	88,800	3,130	63,400
Combined values of cement (portland), clays (ball), lime (2007), sand and gravel (industrial), and values indicated by symbol W	XX	76,900	XX	77,200	XX	42,200
Total	XX	245,000	XX	263,000 r	XX	208,000
Missouri:						
Cement, portland	5,230	515,000 e	4,650	451,000 e	4,420	434,000 e
Clays, common	426	2,880	496	3,470	421	3,020
Sand and gravel:						
Construction	14,300 r	78,500 r	12,400 r	76,200 r	11,500	71,900
Industrial	642	19,400	648	21,400	763	28,900

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2007		2008		2009	
	Quantity	Value	Quantity	Value	Quantity	Value
Missouri—Continued:						
Stone, crushed	83,900	630,000	76,400 [r]	614,000 [r]	67,700	598,000
Combined values of cadmium (byproduct from zinc concentrates), cement (masonry), clays (fire, fuller's earth), copper, gemstones (natural), lead, lime, silver, stone (dimension granite), zinc	XX	1,040,000	XX	892,000 [r]	XX	672,000
Total	XX	2,280,000	XX	2,060,000	XX	1,810,000
Montana:						
Gemstones, natural	NA	386	NA	380	NA	378
Palladium[5] kilograms	12,800	148,000	11,900	136,000	12,700	108,000
Platinum[5] do.	3,860	162,000	3,580	182,000	3,830	149,000
Sand and gravel, construction	16,000 [r]	135,000 [r]	13,400 [r]	110,000 [r]	11,200	85,500
Stone, crushed	1,810	9,800	1,980 [r]	14,000 [r]	1,990	20,400
Combined values of cadmium (byproduct from zinc concentrates), cement, clays (bentonite, common), copper, garnet (industrial), gold, lead, lime, molybdenum concentrates, silver, stone (dimension), talc (crude), zinc	XX	910,000	XX	924,000 [r]	XX	619,000
Total	XX	1,370,000 [r]	XX	1,370,000 [r]	XX	982,000
Nebraska:						
Clays, common	135 [e]	W	109 [e]	W	(4)	W
Gemstones, natural	NA	4	NA	4	NA	4
Sand and gravel, construction	13,500 [r]	71,100 [r]	14,000 [r]	75,400 [r]	12,900	75,500
Stone, crushed	7,690	75,600	7,960	78,100	6,340	59,700
Combined values of cement, lime, sand and gravel [(industrial (2009)], and values indicated by symbol W	XX	(7)	XX	(7)	XX	113,000
Total	XX	147,000 [r]	XX	153,000 [r]	XX	248,000
Nevada:						
Barite	(4)	W	641	29,500	377	18,500
Gold[5] kilograms	186,000	4,170,000	178,000	5,000,000	161,000	5,040,000
Sand and gravel, construction	34,800 [r]	180,000	29,500 [r]	163,000 [r]	21,400	138,000
Silver[5] kilograms	243,000	105,000	235,000	113,000	203,000	95,900
Stone, crushed	12,700	111,000	10,200 [r]	95,100 [r]	8,290	90,500
Combined values of brucite (2007), cement (portland), clays (bentonite, fuller's earth, kaolin), copper, diatomite, gemstones (natural), gypsum (crude), lime, lithium carbonate, magnesite, molybdenum concentrates, perlite (crude), pumice and pumicite, salt, sand and gravel (industrial), stone (dimension), zeolites, and value indicated by symbol W	XX	831,000 [r]	XX	893,000 [r]	XX	639,000
Total	XX	5,400,000 [r]	XX	6,290,000 [r]	XX	6,020,000
New Hampshire:						
Gemstones, natural	NA	6	NA	7	NA	7
Sand and gravel, construction	8,150 [r]	50,300 [r]	8,150 [r]	51,200 [r]	6,930	55,600
Stone:						
Crushed	6,550	67,800	5,170	50,900	4,680	47,000
Dimension, granite	37	5,570	34	4,900	35	4,880
Total	XX	124,000 [r]	XX	107,000 [r]	XX	108,000

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2007		2008		2009	
	Quantity	Value	Quantity	Value	Quantity	Value
New Jersey:						
Clays, common	65	W	--	--	--	--
Gemstones, natural	NA	1	NA	1	NA	1
Sand and gravel:						
Construction	15,700 r	145,000	13,600 r	153,000 r	11,100	116,000
Industrial	1,090	33,200	1,010	31,800	906	30,200
Stone, crushed	20,000	162,000	17,900	155,000	14,500	124,000
Combined values of greensand marl, peat, and value indicated by symbol W	XX	3,220	XX	(7)	XX	(7)
Total	XX	343,000	XX	339,000 r	XX	270,000
New Mexico:						
Clays, common	28	269	14	120	10	90
Copper[5]	108	783,000	104	734,000	56	300,000
Gemstones, natural	NA	24	NA	21	NA	21
Sand and gravel:						
Construction	18,400 r	158,000 r	14,600 r	127,000 r	14,700	118,000
Industrial	(4)	W	(4)	W	--	--
Stone:						
Crushed	7,590	56,700	7,020 r	43,400 r	6,130	40,200
Dimension	(4)	W	27	939	32	986
Combined values of cement, gold, gypsum (crude), helium (Grade-A), lime (2007–08), molybdenum concentrates, perlite (crude), potash, pumice and pumicite, salt, silver, zeolites, and values indicated by symbol W	XX	582,000 r	XX	720,000	XX	427,000
Total	XX	1,580,000	XX	1,630,000 r	XX	886,000
New York:						
Clays, common	699	28,500	745	28,200	605	30,200
Gemstones, natural	NA	96	NA	96	NA	97
Salt	7,990	400,000	7,660	431,000	6,240	426,000
Sand and gravel, construction	34,300 r	286,000 r	34,400 r	260,000 r	31,100	266,000
Stone:						
Crushed	47,300	432,000	41,000 r	384,000 r	96,900	410,000
Dimension	70	12,000	57	16,000	97	28,200
Combined values of cadmium [byproduct from zinc concentrates (2007–08)], cement, garnet (industrial), peat, sand and gravel (industrial), talc [crude (2007–08)], wollastonite, zinc (2007–08)	XX	393,000	XX	354,000	XX	207,000
Total	XX	1,550,000	XX	1,470,000 r	XX	1,370,000
North Carolina:						
Clays:						
Common	1,720	19,500	1,260	12,900	828	4,980
Kaolin	20	792	15	W	9	W
Gemstones, natural	NA	384	NA	659	NA	360
Mica, crude	43	10,300	22	4,580	16	4,430
Sand and gravel:						
Construction	11,500 r	62,900 r	9,770 r	58,800 r	7,570	43,000
Industrial	1,670	31,300	1,510 r	29,400	1,300	28,000

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2007		2008		2009	
	Quantity	Value	Quantity	Value	Quantity	Value
North Carolina—Continued:						
Stone:						
Crushed	70,200	898,000	57,500	806,000	38,500	584,000
Dimension	48	20,400	58	25,200	62	22,300
Combined values of andalusite, feldspar, olivine, phosphate rock, pyrophyllite (crude), and values indicated by symbol W	XX	131,000	XX	150,000 ^{r}	XX	160,000
Total	XX	1,170,000	XX	1,090,000	XX	846,000
North Dakota:						
Clays, common	(4)	(7)	84	549	(4)	(7)
Gemstones, natural	NA	4	NA	4	NA	4
Lime	(4)	(7)	(4)	(7)	(4)	(7)
Sand and gravel:						
Construction	15,000 ^{r}	49,400 ^{r}	12,100 ^{r}	39,200 ^{r}	14,400	47,000
Industrial	(4)	(7)	(4)	(7)	(4)	(7)
Stone, crushed	274	1,270	26	133	985	3,980
Total	XX	50,600 ^{r}	XX	39,800 ^{r}	XX	51,000
Ohio:						
Cement, portland	916	92,000 ^{e}	762	74,000 ^{e}	550	53,000 ^{e}
Clays, common	1,190	16,500	983	15,900	770	13,400
Gemstones, natural	NA	4	NA	4	NA	4
Lime	1,690	159,000	1,670	166,000	1,130	129,000
Sand and gravel:						
Construction	41,000 ^{r}	272,000 ^{r}	33,800 ^{r}	244,000 ^{r}	27,200	241,000
Industrial	1,080	33,000	1,010	34,300	849	26,300
Stone:						
Crushed	68,000	448,000	54,100 ^{r}	446,000 ^{r}	42,700	388,000
Dimension	37	6,050	29 ^{r}	3,660 ^{r}	26	4,790
Combined values of cement (masonry), clays (fire), peat, salt	XX	254,000	XX	262,000 ^{r}	XX	277,000
Total	XX	1,280,000	XX	1,250,000 ^{r}	XX	1,130,000
Oklahoma:						
Clays, common	1,050	5,170	756	3,900	572	2,800
Gemstones, natural	NA	106	NA	4	NA	4
Gypsum, crude	2,820 ^{r}	17,100 ^{r}	2,180 ^{r}	16,200 ^{r}	2,180	15,900
Sand and gravel:						
Construction	16,200	94,200 ^{r}	14,700 ^{r}	95,500 ^{r}	11,600	68,200
Industrial	1,710	44,600	2,040	63,700	1,410	40,300
Stone:						
Crushed	45,800	298,000	47,200 ^{r}	345,000 ^{r}	36,800	308,000
Dimension	65	11,700	53	8,750	35	4,330
Tripoli metric tons	40,600	1,600	86,000	1,800	(4)	W
Combined values of cement, feldspar, helium (Grade–A), iodine (crude), lime, salt, and value indicated by symbol W	XX	261,000	XX	285,000	XX	228,000
Total	XX	734,000 ^{r}	XX	820,000 ^{r}	XX	667,000
Oregon:						
Gemstones, natural	NA	2,150	NA	1,620	NA	1,220
Sand and gravel, construction	21,200	164,000 ^{r}	14,900 ^{r}	121,000 ^{r}	12,200	102,000
Stone, crushed	30,600	211,000	23,500 ^{r}	174,000 ^{r}	15,800	119,000

See footnotes at end of table.

TABLE 5—Continued
NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2007		2008		2009	
	Quantity	Value	Quantity	Value	Quantity	Value
Oregon—Continued:						
Combine values of cement (portland), clays [bentonite, common (2007–08)], diatomite, emery (2008–09), lime, perlite (crude), pumice and pumicite	XX	128,000	XX	106,000	XX	91,500
Total	XX	506,000 r	XX	402,000 r	XX	314,000
Pennsylvania:						
Cement:						
Masonry	304	40,500 e	254	34,000 e	176	23,700 e
Portland	5,660	568,000 e	5,150	510,000 e	3,740	356,000 e
Clays, common	683	4,890	640	4,840	451	3,040
Gemstones, natural	NA	1	NA	1	NA	1
Lime	1,100	112,000	1,130	126,000	985	126,000
Peat	2	79	2	62	3	90
Sand and gravel:						
Construction	18,300	143,000	16,100 r	132,000 r	13,900	114,000
Industrial	685	15,800	677	16,300	618	15,600
Stone:						
Crushed	111,000	960,000	101,000 r	1,140,000	83,000	975,000
Dimension	59	16,200	42	11,100	39	9,670
Tripoli	(4)	(7)	(4)	(7)	(4)	(7)
Total	XX	1,860,000	XX	1,970,000	XX	1,620,000
Rhode Island:						
Gemstones, natural	NA	1	NA	1	NA	1
Sand and gravel:						
Construction	2,410	31,200	2,000 r	27,400 r	1,820	23,300
Industrial	(4)	(7)	(4)	(7)	(4)	(7)
Stone, crushed	2,240	21,200	1,840 r	17,900 r	1,820	20,200
Total	XX	52,400	XX	45,300 r	XX	43,400
South Carolina:						
Cement:						
Masonry	491	60,100 e	323	41,600 e	174	22,000 e
Portland	3,680	355,000 e	2,930	284,000 e	1,870	169,000 e
Clays:						
Common	826	3,990	461	2,130	311	1,300
Fire	37	83	29	66	--	--
Kaolin	297	17,600	199	11,300	144	8,590
Gemstones, natural	NA	1	NA	1	NA	1
Mica, crude	(4)	(7)	(4)	(7)	--	--
Sand and gravel:						
Construction	10,500 r	57,700 r	9,660 r	46,500 r	5,900	32,900
Industrial	837	22,000	679	21,100	441	14,000
Stone:						
Crushed	30,400	290,000	22,500	235,000	18,200	201,000
Dimension	9	850	4	472	3	401
Vermiculite	(4)	(7)	(4)	(7)	(4)	(7)
Total	XX	808,000 r	XX	642,000 r	XX	449,000
South Dakota:						
Clays, common	151	W	155	W	(4)	W
Sand and gravel, construction	14,300 r	52,000 r	12,500 r	48,000 r	10,500	37,900
Silver kilograms	--	--	--	--	8,570	4,040
Stone, crushed	5,430	36,600	5,390	34,300	4,450	29,300

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral		2007 Quantity	2007 Value	2008 Quantity	2008 Value	2009 Quantity	2009 Value
South Dakota—Continued:							
Combined values of cement (portland), feldspar, gemstones (natural), gold, gypsum (crude), iron ore (usable shipped), lime, mica (crude), stone (dimension granite), and values indicated by symbol W		XX	175,000	XX	165,000 r	XX	159,000
Total		XX	263,000 r	XX	247,000 r	XX	230,000
Tennessee:							
Clays:							
Ball		677	30,600	568	25,900	511	22,800
Common		199	1,360	155	1,090	133	816
Sand and gravel:							
Construction		7,640 r	54,500 r	7,180 r	56,200 r	5,360	42,800
Industrial		1,070	32,400	983 r	32,800	783	27,100
Stone, crushed		63,400	559,000	46,200	461,000	40,100	431,000
Combined values of cadmium (byproduct from zinc concentrates), cement, clays (fuller's earth), gemstones (natural), lime, salt, stone (dimension marble), zinc		XX	315,000	XX	281,000 r	XX	150,000
Total		XX	992,000 r	XX	859,000 r	XX	675,000
Texas:							
Cement:							
Masonry		368	52,100 e	274	40,300 e	202	28,300 e
Portland		10,900	1,060,000 e	11,100	1,110,000 e	8,350	815,000 e
Clays:							
Bentonite		64	3,730	73	12,000	54	8,610
Common		1,950	12,600	2,070	13,700	1,800	13,000
Gemstones, natural		NA	202	NA	202	NA	202
Gypsum, crude		2,520 r	15,300 r	1,870 r	13,900 r	1,310	9,330
Lime		1,620	132,000	1,500	128,000	1,040	105,000
Salt		8,950	143,000	9,080	157,000	8,910	164,000
Sand and gravel:							
Construction		96,100 r	656,000 r	88,300 r	631,000 r	70,000	528,000
Industrial		3,280	123,000	3,590 r	139,000	2,130	84,400
Stone:							
Crushed		153,000	1,020,000	150,000 r	1,100,000 r	110,000	782,000
Dimension		243	31,600	269	27,700	236	42,000
Combined values of brucite (2007–08), clays [ball, fire (2009), fuller's earth, kaolin], helium, talc (crude), zeolites		XX	72,100	XX	77,700	XX	69,700
Total		XX	3,320,000 r	XX	3,450,000 r	XX	2,650,000
Utah:							
Beryllium concentrates	metric tons	3,810	NA	4,410	NA	3,030	NA
Clays, common		531	10,400	479	10,200	342	7,230
Gemstones, natural		NA	240	NA	781	NA	783
Salt		2,470	135,000	2,150	139,000	2,000	152,000
Sand and gravel, construction		45,700 r	265,000 r	38,900 r	222,000 r	32,400	190,000
Stone:							
Crushed		13,200	97,800	8,950 r	72,700 r	4,830	39,400
Dimension, sandstone		8	619	9	707	9	844

See footnotes at end of table.

TABLE 5—Continued
NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2007		2008		2009	
	Quantity	Value	Quantity	Value	Quantity	Value
Utah—Continued:						
Combined values of cement (portland), clays (bentonite), copper, gold, gypsum (crude), helium (Grade–A), lime, magnesium compounds, magnesium metal, molybdenum concentrates, phosphate rock, potash, silver	XX	3,370,000	XX	3,730,000	XX	3,510,000
Total	XX	3,880,000	XX	4,170,000 r	XX	3,900,000
Vermont:						
Gemstones, natural	NA	1	NA	1	NA	1
Sand and gravel, construction	5,310 r	35,300 r	4,960 r	33,600 r	4,470	36,700
Stone:						
Crushed	6,460	46,200	5,690 r	47,500 r	5,430	54,900
Dimension	110	35,700	112	35,900	108	30,000
Talc, crude	(4)	(7)	(4)	(7)	(4)	(7)
Total	XX	117,000 r	XX	117,000 r	XX	122,000
Virginia:						
Clays, common	725	7,840	766	8,540	505	5,830
Kyanite	118	29,100	97	25,500	71	20,000
Mica, crude	(9)	1	--	--	--	--
Sand and gravel, construction	12,400 r	116,000 r	10,400 r	111,000 r	8,180	93,100
Stone, crushed	62,600	713,000	57,400 r	712,000 r	42,200	577,000
Combined values of cement, clays (fuller's earth), feldspar, gemstones (natural), iron oxide pigments (crude), lime, salt, sand and gravel (industrial), stone (dimension), titanium concentrates (ilmenite), vermiculite (crude), zirconium concentrates	XX	310,000	XX	318,000 r	XX	260,000
Total	XX	1,180,000	XX	1,170,000 r	XX	955,000
Washington:						
Clays, common	84	170	88	360	(4)	W
Gemstones, natural	NA	49	NA	50	NA	65
Peat	(4)	66	(4)	75	(4)	W
Sand and gravel, construction	45,700 r	325,000 r	39,600 r	326,000 r	29,900	230,000
Stone, crushed	18,000	166,000	17,500 r	168,000 r	14,700	131,000
Combined values of cadmium (byproduct from zinc concentrates), cement (portland), clays [fire (2009)], diatomite, gold (2008–09), lead, lime, olivine, sand and gravel (industrial), stone (dimension miscellaneous), zinc, and values indicated by symbol W	XX	258,000	XX	228,000	XX	289,000
Total	XX	749,000 r	XX	722,000 r	XX	650,000
West Virginia:						
Gemstones, natural	NA	1	NA	1	NA	1
Sand and gravel:						
Construction	675	5,620	426	3,840	410	3,480
Industrial	345	17,600	338	17,200	241	14,700
Stone, crushed	14,600	115,000	15,200 r	127,000 r	12,500	126,000
Combined values of cement, clays (common), lime, peat (2007), salt, stone (dimension sandstone)	XX	87,400	XX	85,300 r	XX	71,600
Total	XX	226,000	XX	234,000 r	XX	215,000

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1,2,3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2007		2008		2009	
	Quantity	Value	Quantity	Value	Quantity	Value
Wisconsin:						
Gemstones, natural	NA	6	NA	7	NA	7
Lime	959	78,000	852	71,500	751	70,100
Peat	(4)	26	(4)	26	--	--
Sand and gravel:						
Construction	39,000 [r]	189,000 [r]	36,200 [r]	190,000 [r]	29,100	143,000
Industrial	2,650	90,100	3,290	120,000	2,730	105,000
Stone:						
Crushed	32,800	191,000	25,900	238,000 [r]	22,900	198,000
Dimension	307	35,900	250	33,300	207	29,800
Total	XX	585,000 [r]	XX	652,000 [r]	XX	546,000
Wyoming:						
Clays:						
Bentonite	4,250	227,000	4,400 [r]	233,000 [r]	3,230	172,000
Common	59	226	37	89	41	104
Gemstones, natural	NA	15	NA	14	NA	14
Sand and gravel, construction	19,500 [r]	98,300 [r]	17,500 [r]	103,000 [r]	17,200	92,200
Stone, crushed	12,500	61,400	12,100	57,100	16,000	75,400
Combined values of cement (portland), gypsum (crude), helium (Grade–A), lime, soda ash, stone [dimension (2008–09)], zeolites (2007)	XX	1,370,000	XX	1,640,000	XX	1,460,000
Total	XX	1,760,000	XX	2,030,000 [r]	XX	1,800,000
Undistributed:						
Connecticut, Delaware, Maryland (2007), Massachusetts, Nebraska (2007–08), New Jersey (2008–09), North Dakota, Pennsylvania, Rhode Island, South Carolina, Vermont, Undistributed	XX	190,000	XX	167,000 [r]	XX	89,500

[e]Estimated. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; included in "Combined values" data for each State. XX Not applicable. -- Zero.

[1]Table includes data available through July 26, 2011.

[2]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[3]Data are rounded to no more than three significant digits; may not add to totals shown.

[4]Withheld to avoid disclosing company proprietary data.

[5]Recoverable content of ores, etc.

[6]Grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.

[7]Withheld to avoid disclosing company proprietary data; value included in "Undistributed."

[8]Excludes attapulgite; included in "Combined values."

[9]Less than ½ unit.

TABLE 6
NONFUEL RAW MINERAL PRODUCTION IN THE COMMONWEALTH OF PUERTO RICO AND ISLANDS ADMINISTERED BY THE UNITED STATES[1, 2, 3]

(Thousand metric tons and thousand dollars)

Mineral	2007		2008		2009	
	Quantity	Value	Quantity	Value	Quantity	Value
Puerto Rico:						
Cement, portland	1,390	W	1,300	W	936	W
Clays, common	96	547	75	437	54	328
Lime[e]	11	2,250	11	998	11	1,750
Salt	45	1,500	45	1,500	45	1,500
Stone, crushed	13,400	100,000	11,000 [r]	96,000 [r]	8,370	68,700
Total	XX	105,000	XX	98,900 [r]	XX	72,300
Administered Islands:						
American Samoa, stone, crushed	W	W	W	W	W	W
Guam, stone, crushed	329	3,760	325	3,780	296	3,380
Virgin Islands, stone, crushed	W	W	W	W	W	W
Total	XX	3,760	XX	3,780	XX	3,380

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data. XX Not applicable.

[1] Table includes data available through July 26, 2011.

[2] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[3] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 7

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS[1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2008		2009	
		Quantity	Value	Quantity	Value
Metals:					
Aluminum:					
Crude and semicrude	metric tons	3,280,000	9,020,000	2,710,000	5,910,000
Manufactures	do.	150,000	683,000	122,000	479,000
Antimony:					
Metal, alloys, waste and scrap	do.	366	1,360[r]	385	2,000
Oxide, antimony content	do.	1,830	10,200	1,710	9,660
Arsenic metal, arsenic content	do.	1,050	2,110	354	793
Bauxite and alumina:					
Alumina, calcined equivalent		1,150	684,000	946	488,000
Bauxite:					
Calcined, refractory and other grade		10	1,600	21	10,900
Crude and dried		14	4,000[r]	20	5,580
Specialty aluminum compounds, sulfate, chloride, fluoride-based	metric tons	41,600	50,400	28,500	32,500
Beryllium, unwrought, and waste and scrap, other including articles not elsewhere specified, beryllium content	kilograms	113,000	16,500	22,900	11,700
Bismuth, metal, alloys, waste and scrap, bismuth content	do.	375,000	6,730	397,000	5,820
Cadmium:					
Metal	do.	126,000	901	249,000	537
Sulfide, gross weight	do.	241,000	125	16,200	8
Unwrought and powder	do.	295,000	1,370	276,000	1,270
Waste and scrap	do.	--	--	137,000	319
Chromium:					
Ores and concentrate	metric tons	7,000	4,370	2,500	1,610
Metals and alloys:					
Metal, unwrought powders, waste and scrap, other	do.	998	20,400	411	13,300
Ferroalloys, high-carbon, low-carbon, ferrochromium-silicon	do.	24,500	43,100	4,780	6,820
Chemicals:					
Oxide, trioxide, other	do.	21,000	38,900	12,000	27,900
Sulfates	do.	52	362	16	114
Salts of oxometallic or peroxometallic acids, zinc and lead chromate, sodium dichromate, potassium dichromate, other	do.	32,800	31,200	20,500	23,100
Pigments and preparations	do.	1,230	10,600	1,220	13,800
Cobalt:					
Acetates and chlorides	do.	346	6,320	658	8,370
Oxides and hydroxides	do.	531	19,400	225	5,550
Metal:					
Unwrought, powders, waste and scrap, mattes, other intermediate products of metallurgy	do.	2,380	112,000	2,120	77,300
Wrought and cobalt articles	do.	1,370	104,000	NA	NA
Copper:					
Unmanufactured, does not include unalloyed scrap, copper content	do.	407,000	1,920,000	299,000	1,280,000
Semimanufactures	do.	222,000	1,870,000	194,000	1,140,000
Scrap, alloyed and unalloyed	do.	908,000	2,960,000	843,000	2,010,000
Ferroalloys not listed elsewhere:					
Ferrophosphorous	do.	2,350	4,590	1,130	2,080
Other	do.	9,360	16,300	3,130	6,840
Gold:					
Ores and concentrates	kilograms	2,430	52,300	2,160	48,600
Dore and precipitates	do.	106,000	3,000,000	97,400	3,000,000
Bullion, refined	do.	459,000[r]	13,100,000	281,000	8,760,000
Waste and scrap	do.	886,000	1,970,000	728,000	1,750,000

See footnotes at end of table.

TABLE 7—Continued
U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS[1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2008		2009	
		Quantity	Value	Quantity	Value
Metals—Continued:					
Gold—Continued:					
Metal powder	kilograms	1,210	25,300	329	8,460
Compounds	do.	2,920,000	67,900	2,680,000	64,600
Iron and steel:					
Steel mill products		12,200	NA	8,420	NA
Fabricated steel products		1,900	NA	1,560	NA
Cast iron and steel products		304	NA	238	NA
Iron and steel scrap:					
Ferrous, includes tinplate and terneplate, excludes used rails for rerolling and other uses and ships, boats, and other vessels for scrapping		21,500	10,400,000	22,400	7,120,000
Pig iron, all grades		51	11,400	11	4,200
Direct-reduced iron, steelmaking grade	metric tons	804	97	271	38
Ships, boats, and other vessels for scrapping		4	354	4	773
Used rails for rerolling and other uses, includes mixed (used plus new) rails		76	54,900	59	38,700
Iron ore		11,100	1,240,000	3,920	356,000
Lead:					
Base bullion, lead content	metric tons	614	2,040	34	113
Ore and concentrates, lead content	do.	277,000	243,000	287,000	275,000
Unwrought and alloys, lead content	do.	68,100	119,000	77,600	80,100
Wrought and alloys, lead content	do.	6,150	9,880	4,310	8,280
Scrap, gross weight	do.	175,000	92,800	140,000	72,000
Magnesium:					
Waste and scrap, magnesium content	do.	2,600	5,420	2,280	5,200
Metal, magnesium content	do.	3,100	9,770	6,120	20,500
Alloys, gross weight	do.	6,760	29,900	9,190	40,400
Powder, sheets, tubing, ribbons, wire, other forms, gross weight	do.	1,950	30,200	2,050	30,500
Manganese, gross weight:					
Ores and concentrates with 20% or more manganese	do.	48,300	10,700	15,300	3,830
Ferromanganese, all grades	do.	23,400	20,600	24,200	27,900
Silicomanganese	do.	7,140	9,020	18,800	17,500
Metal, including alloys and waste and scrap	do.	4,580	11,600	3,470	9,040
Dioxide	do.	11,000	14,600	8,420	13,400
Mercury:					
Metal	do.	732	10,100	753	10,300
Amalgams of precious metals whether or not chemically defined	do.	925	564,000	154	238,000
Molybdenum:					
Ore and concentrates, including roasted and other, molybdenum content	do.	32,700	1,810,000	29,600	631,000
Chemicals:					
Oxides and hydroxides, gross weight	do.	16,700	428,000	10,600	159,000
Molybdates, all, gross weight	do.	1,540	46,700	1,500	18,000
Ferromolybdenum, molybdenum content	do.	1,290	62,400	827	22,400
Other, includes powders, unwrought, bars and rods, waste and scrap, wire, other, gross weight	do.	2,190	192,000	1,790	112,000
Nickel, nickel content:					
Primary, unwrought and chemicals	do.	11,600	345,000	7,020	313,000
Secondary, stainless steel scrap and waste and scrap	do.	94,600	1,340,000	90,000	814,000
Wrought, not alloyed, bars, rods, profiles, wire, sheets, strip, foil, tubes, pipes	do.	1,700	45,500	975	24,200
Alloyed, unwrought ingot, bars, rods, profiles, wire, sheets, strip, foil, tubes, pipes, other alloyed articles, gross weight	do.	42,100	1,730,000	30,700	1,120,000

See footnotes at end of table.

TABLE 7—Continued

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS[1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2008		2009	
		Quantity	Value	Quantity	Value
Metals—Continued:					
Niobium (columbium) and tantalum:					
Niobium:					
Ores and concentrates	kilograms	62,800	2,010	17,000	954
Ferroniobium	do.	1,130,000	12,500	240,000	2,740
Tantalum:					
Ores and concentrates, includes synthetic	do.	277,000	2,790	318,000	2,900
Unwrought powders, waste and scrap, unwrought alloys and metal	do.	462,000	89,800	179,000	50,100
Wrought	do.	104,000	49,300	52,200	26,900
Platinum-group metals:					
Palladium, palladium content	do.	26,400	197,000	30,300	229,000
Platinum, includes waste and scrap and metal, platinum content	do.	70,300	1,760,000	47,100	1,040,000
Iridium, osmium, ruthenium, gross weight	do.	6,450	80,600	4,020	34,400
Rhodium, rhodium content	do.	1,980	302,000	1,220	48,400
Rare earths, estimated rare-earth oxide content:					
Cerium compounds	do.	1,380,000	12,200	840,000	8,040
Compounds, inorganic and organic	do.	663,000	7,610	455,000	6,210
Metals, including scandium and yttrium	do.	1,390,000	18,600	4,920,000	15,700
Ferrocerium and other pyrophoric alloys	do.	4,490,000	21,200	2,970,000	28,000
Selenium and tellurium:					
Selenium, selenium content	do.	545,000	8,920	613,000	10,300
Tellurium, tellurium content	do.	50,000	3,030	8,130	1,210
Silicon, gross weight:					
Ferrosilicon	metric tons	17,700	29,500 [r]	14,200	16,900
Metal	do.	35,400	2,260,000	37,900	2,070,000
Silver:					
Bullion, silver content	kilograms	413,000	203,000	167,000	93,600
Dore, silver content	do.	94,800	36,200	130,000	72,700
Metal powder, gross weight	do.	890,000	473,000	834,000	434,000
Nitrate, gross weight	do.	34,900	3,260	27,900	2,690
Ores and concentrates, silver content	do.	130,000	50,300	122,000	55,400
Semimanufactured forms containing 99.5% or more by weight of silver, gross weight	do.	720,000	199,000	525,000	252,000
Waste and scrap, gross weight	do.	2,570,000	4,290,000	2,480,000	4,300,000
Unwrought, other, gross weight	do.	47,700	15,700	59,000	21,200
Thorium:					
Ore, monazite concentrate	do.	--	--	18,000	269
Thorium and thorium-bearing materials, compounds	do.	12,700	1,250	4,730	379
Tin:					
Ingots and pigs	metric tons	9,800	62,000	3,170	22,200
Tin scrap and other tin bearing material, except tinplate scrap, includes rods, profiles, wire, powders, flakes, tubes, pipes	do.	14,500	65,600	11,600	46,200
Tinplate and terneplate	do.	247,000	192,000	224,000	175,000
Titanium:					
Metal, waste and scrap, unwrought, wrought products and castings, ferrotitanium and ferrosilicon titanium	do.	34,600	1,290,000	23,300	799,000
Ores and concentrates	do.	14,900	8,590	14,800	8,230
Pigment, dioxide and oxide	do.	733,000	1,470,000	649,000	1,310,000
Tungsten, tungsten content:					
Ammonium paratungstate	do.	621	10,100	375	5,990
Carbide powder	do.	1,340	53,300	469	19,600
Metal powders	do.	981 [e]	57,100	361 [e]	25,500

See footnotes at end of table.

TABLE 7—Continued
U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS[1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2008 Quantity	2008 Value	2009 Quantity	2009 Value
Metals—Continued:					
Tungsten, tungsten content—Continued:					
Miscellaneous tungsten-bearing materials, ferrotungsten, ferrosilicon tungsten, unwrought, waste and scrap, wrought, compounds	metric tons	2,540	84,200	1,520	48,600
Ores and concentrates	do.	496 ᵉ	14,500	38 ᵉ	1,080
Vanadium:					
Aluminum-vanadium master alloy, gross weight	kilograms	21,900,000	76,200	11,200,000	27,800
Ferrovanadium, vanadium content	do.	281,000	12,600	672,000	15,000
Metal, including waste and scrap, gross weight	do.	57,100	3,740	22,700	1,040
Pentoxide, anhydride, vanadium content	do.	249,000	5,650	401,000	4,970
Other oxides and hydroxides, vanadium content	do.	1,040,000	11,300	506,000	5,270
Zinc:					
Compounds, chloride, chromates of zinc or of lead, compounds n.s.p.f.[3], lithopone, oxide, sulfate, sulfide, gross weight	metric tons	49,500	76,500	25,400	47,500
Ores and concentrates, zinc content	do.	725,000	598,000	785,000	656,000
Rolled	do.	4,970	20,900	6,160	17,700
Slab	do.	3,250	3,260	2,960	3,070
Zirconium:					
Ferrozirconium	do.	316	574	566	1,140
Ores and concentrates	do.	42,100 ʳ	51,100	39,600	36,300
Oxide, includes germanium oxides and zirconium dioxides	do.	2,970	42,400	3,050	31,400
Unwrought powders	do.	344	10,400	165	7,660
Waste and scrap	do.	2,330	180,000	2,140	192,000
Total		XX	69,300,000 ʳ	XX	49,100,000
Industrial Minerals:					
Abrasives, manufactured:					
Aluminum oxide, crude	metric tons	21,900	59,000	12,300	32,000
Metallic abrasives	do.	34,400	48,500	25,900	32,200
Silicon carbide, crude, ground and refined	do.	17,000	46,600	20,700	37,700
Asbestos, includes reexports:					
Manufactured		NA	33,200	NA	24,500
Unmanufactured	metric tons	368	345	59	69
Barite, natural barium sulfate	do.	61,600	10,500	49,300	10,200
Boron minerals and compounds:					
Boric acid, includes orthoboric and anhydrous		303	165,000	171	109,000
Sodium borates		519	192,000	417	176,000
Bromine:					
Compounds, includes methyl bromine and ethylene dibromide, bromine content	metric tons	3,500 ʳ	9,120 ʳ	2,310	6,510
Elemental, gross weight	do.	6,140	7,100	3,810	5,930
Cement, hydraulic and clinker[4]		823	102,000	884	107,000
Clays:					
Ball		65	4,580	35	2,430
Bentonite		1,090	161,000	709	100,000
Fire		393	49,600	328	42,800
Fuller's earth		127	44,000 ʳ	90	28,500
Kaolin		2,960	606,000	2,290	459,000
Other, n.e.c.[5], includes chamotte or dinas earth, activated clays and earths, artificially activated clays		466 ʳ	72,700 ʳ	374	69,500
Diamond:					
Gemstones, natural, including reexports	thousand carats	34,000	14,700,000	25,200	9,940,000

See footnotes at end of table.

TABLE 7—Continued

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS[1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2008		2009	
		Quantity	Value	Quantity	Value
Industrial minerals—Continued:					
Diamond—Continued:					
Industrial including exports and reexports:					
Unworked	thousand carats	1,280	28,000	947	17,500
Powder, dust and grit, natural and synthetic	do.	125,000	61,700	76,900	37,600
Diatomite		151	67,700	88	41,100
Feldspar	metric tons	14,600	2,390	7,520	1,150
Fluorspar	do.	18,800	3,340	14,100	2,230
Garnet, industrial	do.	12,500	9,050	13,200	10,700
Graphite, natural and artificial	do.	62,800	182,000	46,400	130,000
Gypsum and gypsum products:					
Crude		149	20,500	156	16,000
Plasters		135	47,400	155	37,800
Boards		98	133,000	665	120,000
Other		XX	55,400	XX	50,200
Helium, Grade–A	million cubic meters	70	152,000	71	160,000
Iodine:					
Crude, resublimed	metric tons	950	17,400	1,160	22,900
Potassium iodide	do.	568	11,300	126	2,720
Iron oxide pigments and hydroxides:					
Pigment grade	do.	4,740	12,100	5,640	15,500
Other grade	do.	46,900	31,800	11,300	18,500
Kyanite, andalusite, sillimanite[e]		36	10,400	26	7,510
Lime		174	27,100	108	18,500
Lithium chemicals:					
Carbonate	metric tons	2,720	15,800 [r]	1,030	7,130
Hydroxide	do.	5,680	40,700 [r]	4,400	31,600
Magnesium compounds:					
Compounds, chlorides, hydroxide and peroxide, sulfates	do.	38,000	29,100	37,800	28,300
Magnesite, crude and processed:					
Caustic-calcined magnesia	do.	890	779	503	296
Dead-burned and fused magnesia	do.	22,100	13,100	8,390	5,950
Other magnesia	do.	18,100	18,900	12,700	13,500
Crude	do.	21,000	3,350	10,500	1,480
Mica:					
Scrap and flake:					
Powder	metric tons	6,630	7,810	5,940	8,850
Waste	do.	2,430	731	2,090	1,600
Sheet:					
Unworked	do.	105	238	96	437
Worked	do.	1,920	18,600	1,020	15,300
Nitrogen, major compounds, gross weight		9,370	NA	9,280	NA
Peat		186	17,800	77	8,570
Perlite, crude[e]	metric tons	37,000	NA	33,000	NA
Potash:					
Potassium chloride	do.	104,000	NA	342,000	NA
Potassium sulfates, all grades	do.	585,000	NA	355,000	NA
Potassium nitrate	do.	5,090	6,050	8,450	6,250
Pumice and pumicite		15	7,220	11	5,100
Salt		1,030	65,900	1,450	74,100

See footnotes at end of table.

TABLE 7—Continued
U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS[1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2008		2009	
		Quantity	Value	Quantity	Value
Industrial minerals—Continued:					
Sand and gravel:					
Construction:					
Sand		98	18,000	79	19,000
Gravel		294	4,380	360	4,050
Industrial		3,100	260,000	2,150	175,000
Silica, special stone products		NA	8,730 r	NA	7,640
Soda ash		5,370	939,000	4,410	838,000
Stone:					
Crushed		1,240	61,600	1,260	58,300
Dimension		XX	65,700	XX	48,300
Strontium compounds:					
Carbonate, precipitated	kilograms	118,000	114	160,000	107
Oxide, hydroxide, peroxide	do.	749,000 r	641 r	615,000	358
Sulfur:					
Elemental		953 r	272,000	1,430	82,200
Sulfuric acid, 100% H_2SO_4	metric tons	262,000	42,700	254,000	23,900
Talc, excludes powders–talcum (in package), face, compact		244	46,000	188	37,600
Vermiculite[e]		5	985	3	610
Wollastonite[e]	metric tons	30,000	9,000	35,000	10,700
Zeolites[e]	do.	200	46	200	47
Total		XX	19,100,000 r	XX	13,400,000
Grand total		XX	88,400,000 r	XX	62,500,000

[e] Estimated. [r] Revised. do. Ditto. NA Not available. XX Not applicable. -- Zero.

[1] Table includes data available through July 26, 2011.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Not specifically provided for.

[4] Excludes Puerto Rico.

[5] Not elsewhere classified.

TABLE 8

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS[1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2008		2009	
		Quantity	Value[3]	Quantity	Value[3]
Metals:					
Aluminum:					
Crude and semicrude	metric tons	4,200,000	12,500,000	4,110,000	7,980,000
Manufactures	do.	325,000	1,210,000	264,000	732,000
Antimony:					
Metal	do.	7,050	29,700	4,750	19,600
Ore and concentrate, antimony content	do.	164	828	167	1,010
Oxide, antimony content	do.	21,800	124,000	15,200	81,000
Arsenic:					
Acid	do.	115	682	3	11
Metal	do.	376	2,610	438	1,890
Sulfide	do.	(4)	11	77	334
Trioxide	do.	6,320	2,920	6,130	2,740
Bauxite and alumina:					
Alumina, calcined equivalent		2,530	1,100,000	1,860	613,000
Bauxite:					
Calcined, refractory and other grade		1,110	178,000	461	91,800
Crude and dried		10,500	277,000	6,970	208,000
Specialty aluminum compounds, sulfate, chloride, fluoride-based	metric tons	62,000	72,400	30,700	30,600
Beryllium, ore, concentrates, oxide, hydroxide, unwrought including powders, waste and scrap, other, beryllium-copper master alloys, beryllium-copper plates, sheets, strip, beryllium content	kilograms	77,600 [r]	20,500	23,800	5,720
Bismuth, metallic	do.	1,930,000	44,700	1,250,000	20,600
Cadmium:					
Metal	do.	44,000	565	4,940	371
Sulfide, gross weight	do.	439,000	3,040	135,000	2,430
Unwrought and powder	do.	153,000	5,090	117,000	1,110
Chromium:					
Chromite ore	metric tons	197,000	44,800	77,200	17,500
Metals and alloys:					
Ferroalloys, high-carbon, low-carbon, ferrochromium-silicon	do.	533,000	1,170,000	248,000	294,000
Metal, unwrought powders, waste and scrap, other	do.	13,100	145,000	7,570	74,900
Chemicals:					
Oxides, hydroxides, trioxide and other	do.	11,400	32,300	9,100	28,000
Sulfates	do.	56	92	71	88
Salts of oxometallic or peroxometallic acids, zinc and lead chromate, sodium dichromate, potassium dichromate, other	do.	33,600	30,800	15,300	18,100
Carbide	do.	129	2,460	165	3,060
Pigments and preparations based on chromium	do.	2,100	10,700	1,700	8,650
Cobalt:					
Metal:					
Alloys, unwrought, waste and scrap, wrought, cobalt articles	do.	1,570	59,400	NA	NA
Unwrought, excluding alloys and waste and scrap, includes cathode and metal powder, may include intermediate products of cobalt metallurgy	do.	8,430	618,000	5,870	198,000
Oxide and hydroxides	do.	1,110	63,400	1,460	37,500
Other forms, includes acetates, carbonates, chlorides, sulfates	do.	4,710	49,900	2,130	27,300
Copper:					
Unmanufactured, does not include unalloyed scrap, copper content	do.	848,000	6,210,000	733,000	3,510,000
Semimanufactures	do.	301,000	2,090,000 [r]	225,000	1,050,000
Scrap, alloyed and unalloyed	do.	106,000 [r]	485,000	71,800	237,000

See footnotes at end of table.

TABLE 8—Continued
U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS[1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2008		2009	
		Quantity	Value[3]	Quantity	Value[3]
Metals—Continued:					
Ferroalloys not listed elsewhere:					
Ferrophosphorus	metric tons	10,200	7,530	138	617
Other	do.	12,900	36,700	4,710	13,900
Gallium:					
Unwrought and waste and scrap	kilograms	41,100	18,500	35,900	12,600
Gallium arsenide wafers, doped and undoped	do.	166,000	155,000	145,000	131,000
Germanium, wrought, unwrought, waste and scrap, gross weight	do.	40,200	39,600	29,400	39,100
Gold:					
Ores and concentrates	kilograms	27,500	15,700		
Dore and precipitates	do.	85,100	1,830,000	146,000	4,260,000
Bullion, refined	do.	118,000	3,190,000	127,000	3,580,000
Waste and scrap	do.	36,500	485,000	43,400	589,000
Metal powder	do.	324	6,620	476	8,760
Compounds	do.	102,000	2,210	64,300	1,430
Indium, unwrought metal	do.	144,000	69,500	105,000	35,200
Iron and steel:					
Steel mill products		29,000	NA	14,700	NA
Fabricated steel products		5,220 r	NA	3,530	NA
Cast iron and steel products		777	NA	464	NA
Stainless steel	metric tons	586,000	NA	345,000	NA
Iron and steel scrap:					
Ferrous, includes tinplate and terneplate, excludes used rails for rerolling and other uses and ships, boats, and other vessels for scrapping		3,600	1,450,000	2,990	814,000
Pig iron, all grades		4,980	2,800,000	2,420	877,000
Direct-reduced iron, steelmaking grade		2,340	971,000	1,020	304,000
Ships, boats, and other vessels for scrapping		(4) r	18	(4)	79
Used rails for rerolling and other uses, includes mixed (used plus new) rails		151	80,600	57	17,700
Iron ore		9,250	918,000	3,870	376,000
Lead:					
Pigs and bars, lead content	metric tons	309,000	660,000	251,000	480,000
Pigments and compounds, lead content	do.	26,200	62,400	28,100	46,800
Scrap, reclaimed, includes ash and residues, lead content	do.	1,290	2,040	1,330	2,620
Wrought, all forms, including wire and powders, gross weight	do.	3,250	14,000	1,340	5,950
Magnesium:					
Waste and scrap, gross weight	do.	24,100	58,800	20,900	40,300
Metal, gross weight	do.	44,300	190,000	21,400	86,800
Alloys, magnesium content	do.	13,000	74,100	4,790	29,800
Powder, sheets, tubing, ribbons, wire, other forms, magnesium content	do.	1,970	14,700	205	4,170
Manganese:					
Ores and concentrates with 20% or more manganese, manganese content	do.	289,000	154,000	154,000	82,600
Ferromanganese, all grades, manganese content	do.	351,000	1,130,000	121,000	215,000
Silicomanganese, manganese content	do.	245,000	682,000	83,500	135,000
Metal, unwrought, other wrought, waste and scrap, gross weight	do.	31,700	116,000	23,000	57,800
Chemicals, manganese dioxide and potassium permanganate, gross weight	do.	23,600	39,600	18,600	45,800
Mercury:					
Metal	do.	155	1,700	206	1,350
Amalgams of precious metals whether or not chemically defined	do.	15	66,800	14	31,300

See footnotes at end of table.

TABLE 8—Continued
U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS[1,2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2008		2009	
		Quantity	Value[3]	Quantity	Value[3]
Metals—Continued:					
Molybdenum:					
Ores and concentrates, including roasted and other, molybdenum content	metric tons	10,200	512,000	7,520	150,000
Chemicals, gross weight:					
Oxides and hydroxides	do.	335	12,900	209	3,330
Molybdates, all, molybdenum content	do.	235[r]	15,300	657	20,500
Orange	do.	373	3,110	269	2,170
Ferromolybdenum, molybdenum content	do.	2,320	166,000	2,030	50,100
Other, includes powders, unwrought, bars and rods, waste and scrap, wire, other, gross weight	do.	1,420	105,000	970	43,000
Nickel, nickel content:					
Primary, chemicals and unwrought	do.	129,000	3,200,000	99,900	1,480,000
Secondary, stainless steel scrap and waste and scrap	do.	20,100	427,000	17,700	249,000
Wrought, not alloyed, bars, rods, profiles, wire, sheets, strip, foil, tubes, pipes	do.	947[r]	33,800[r]	409	14,000
Alloyed, unwrought ingot, bars, rods, profiles, wire, sheets, strip, foil, tubes, pipes, other alloyed articles	do.	23,700[r]	748,000[r]	17,300	439,000
Niobium (columbium) and tantalum:					
Niobium:					
Ores and concentrates	kilograms	15,600	87	4,960	360
Oxide	do.	1,220,000	31,300	1,060,000	29,000
Ferroniobium	do.	11,000,000	245,000	4,490,000	109,000
Unwrought and powder	do.	1,130,000	47,500	699,000	24,100
Tantalum:					
Ores and concentrates, includes synthetic concentrates	do.	1,170,000	63,100	357,000	13,600
Unwrought powders, waste and scrap, unwrought alloys and metal	do.	833,000	113,000	613,000	92,800
Wrought	do.	101,000	23,200	75,600	20,800
Platinum-group metals, metal content:					
Platinum, grains and nuggets, sponge, other unwrought, other, waste and scrap, coins	do.	150,000	3,420,000	183,000	2,080,000
Palladium, unwrought and other	do.	120,000	1,350,000	69,700	631,000
Iridium, unwrought and other forms	do.	2,550	36,600	1,520	20,800
Osmium, unwrought	do.	11	101	68	551
Ruthenium, unwrought	do.	49,800	426,000	21,200	55,700
Rhodium, unwrought and other forms	do.	12,600	2,470,000	11,200	530,000
Rare earths, estimated equivalent rare-earth oxide (REO) content:					
Cerium compounds, including oxides, hydroxides, nitrates, sulfate chlorides, oxalates	do.	2,080,000	12,800	1,500,000	9,070
Yttrium compounds content by weight greater than 19% but less than 85% oxide equivalent	do.	9,920	6,770	6,920	565,000
Compounds, including oxides, hydroxides, nitrates, other compounds except chlorides	do.	8,810,000	119,000	5,120,000	67,500
Mixtures of REOs except cerium oxide	do.	2,390,000	22,600	4,750,000	23,500
Metals, whether intermixed or alloyed	do.	679,000	4,940	226,000	4,870
Mixtures of rare-earth chlorides, except cerium chloride	do.	1,310,000	17,600	411,000	4,930
Ferrocerium and other pyrophoric alloys	do.	125,000	2,380	102,000	2,620
Rhenium:					
Metal	do.	35,900	72,800	21,500	53,100
Ammonium perrhenate	do.	11,200[r]	24,200	14,300	13,700
Selenium and tellurium:					
Selenium, selenium content:					
Selenium	do.	508,000	26,400	260,000	12,700
Dioxide	do.	11,000	958	3,420	210
Tellurium, tellurium content	do.	102,000	17,700	84,000	11,300

See footnotes at end of table.

TABLE 8—Continued
U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS[1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2008		2009	
		Quantity	Value[3]	Quantity	Value[3]
Metals—Continued:					
Silicon, gross weight:					
Ferrosilicon	metric tons	281,000	395,000	103,000	126,000
Metal	do.	172,000	678,000	116,000	477,000
Silver:					
Ash and residues, silver content	kilograms	4,850	1,290 r	505	151
Bullion, silver content	do.	3,860,000	1,850,000	2,800,000	1,310,000
Dore, silver content	do.	574,000	717,000	653,000	439,000
Metal powder, gross weight	do.	61,000	8,870	247,000	36,400
Nitrate, gross weight	do.	10,700	4,280	835	241
Ores and concentrates, silver content	do.	32	31 r	87	9
Semimanufactured forms containing 99.5% or more by weight of silver, gross weight	do.	418,000	134,000	476,000	176,000
Waste and scrap, gross weight	do.	5,190,000	681,000	4,760,000	372,000
Unwrought, other, gross weight	do.	245,000	88,000	135,000	56,100
Thallium, unwrought powders, waste and scrap, other	do.	1,770	311	2,030	312
Thorium:					
Ore, monazite concentrate		--	--	26,000	20
Thorium and thorium-bearing materials, compounds	do.	692	121	2,250	275
Tin, gross weight:					
Compounds	metric tons	800	15,800	601	8,180
Dross, skimmings, scrap, residues, alloys, n.s.p.f.[5]	do.	24,200	33,300	81,300	23,400
Metal, unwrought	do.	36,300	636,000	33,000	404,000
Miscellaneous, includes tinfoil, tin powder, flitters, metallics, manufactures, n.s.p.f.[5]	do.	XX	71,100	XX	36,200
Tinplate and terneplate, gross weight	do.	292,000	271,000	295,000	366,000
Tinplate scrap, gross weight	do.	25,900	7,040	27,100	5,190
Titanium:					
Concentrate:					
Ilmenite	do.	433,000	68,600	250,000	21,800
Rutile, natural and synthetic	do.	487,000	232,000	279,000	141,000
Metal:					
Waste and scrap	do.	10,400	68,900	4,770	17,600
Unwrought	do.	23,900	278,000	16,600	178,000
Ingots	do.	1,340	36,800	531	13,300
Powder	do.	134	7,710	24	2,390
Other	do.	59	1,570	18	1,220
Wrought products and castings, includes bar, castings, foil, pipe, plate, profile, rod, sheet, strip, tube, wire, other	do.	8,350	349,000	6,930	292,000
Ferrotitanium and ferrosilicon titanium	do.	2,830	14,900	2,540	6,750
Pigment, dioxide and oxide	do.	183,000	393,000	175,000	385,000
Titaniferous iron ore	do.	140,000	44,600	10,000	532
Titaniferous slag	do.	461,000	187,000	414,000	168,000
Tungsten, tungsten content:					
Ammonium paratungstate	do.	2,510	66,700	2,540	52,600
Ferrotungsten and ferrosilicon tungsten	do.	309	10,500	46	1,260
Miscellaneous tungsten-bearing materials, metal powders, carbide powder, unwrought, waste and scrap, wrought, oxides, calcium tungstate, other tungstates, other compounds	do.	6,230	242,000	3,830	135,000
Ores and concentrates	do.	3,990	95,900	3,590	72,900

See footnotes at end of table.

TABLE 8—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS[1,2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2008		2009	
		Quantity	Value[3]	Quantity	Value[3]
Metals—Continued:					
Vanadium:					
Aluminum-vanadium master alloy, gross weight	kilograms	618,000	2,760	282,000	979
Ferrovanadium, vanadium content	do.	2,720,000 r	158,000	353,000	12,600
Metal, including waste and scrap, gross weight	do.	4,600	409	21,700	940
Miscellaneous chemicals, sulfates and vanadates, vanadium content	do.	189,000	4,350	231,000	3,570
Pentoxide, anhydride, vanadium content	do.	3,700,000	115,000	1,120,000	16,500
Vanadium-bearing ash and residues from the manufacture of iron and steel, vanadium oxide content	do.	1,040,000 r	18,000 r	791,000	12,300
Other oxides and hydroxides, vanadium content	do.	144,000	4,320	25,200	551
Zinc:					
Compounds, chloride, chromates of zinc or of lead, compounds n.s.p.f.[5], lithopone, oxide, sulfate, sulfide, gross weight	metric tons	161,000	248,000	104,000	127,000
Ores and concentrates, zinc content	do.	63,200	73,200	74,200	68,300
Rolled	do.	3,330	17,100	3,010	13,500
Slab, refined	do.	752,000	1,480,000	686,000	1,080,000
Zirconium and hafnium:					
Hafnium, unwrought, including powders	do.	12	3,850	5	2,080
Zirconium:					
Ferrozirconium	do.	129	594	(4)	7
Ores and concentrates	do.	34,400	30,200	14,400	17,100
Oxide, includes germanium oxides and zirconium oxides	do.	5,060	77,400	2,810	43,800
Unwrought powder	do.	94	2,790	22	1,890
Waste and scrap	do.	939	59,200	955	58,400
Total		XX	65,700,000	XX	41,300,000
Industrial minerals:					
Abrasives, manufactured:					
Aluminum oxide, crude, ground and refined	do.	285,000	175,000	64,200	53,700
Metallic abrasives	do.	36,600	28,300	15,800	12,100
Silicon carbide, crude, ground and refined	do.	127,000	149,000	78,000	74,500
Asbestos:					
Chrysotile and other unspecified type	metric tons	1,460	1,090	869	684
Products with basis of asbestos, cellulose, or other minerals		NA	19,500	NA	13,300
Barite:					
Chloride, oxide, hydroxide, peroxide, precipitated carbonate	metric tons	9,950	12,600	4,170	6,250
Crude	do.	1,920,000	160,000	572,000	30,000
Ground	do.	688,000	35,000	851,000	58,100
Other sulfates	do.	13,900	12,900	10,600	10,900
Boron minerals and compounds:					
Borax		1	566	(4)	376
Boric acid		50	26,200	36	26,100
Colemanite		30	8,880	31	8,630
Ulexite		75	22,600	28	11,300
Bromine:					
Compounds, contained bromine	metric tons	39,300 r	95,100 r	32,800	80,300
Elemental	do.	1,950	2,280	1,390	3,020
Cement, hydraulic and clinker[6]		11,400	779,000	6,770	502,000

See footnotes at end of table.

TABLE 8—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS[1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2008		2009	
		Quantity	Value[3]	Quantity	Value[3]
Industrial minerals—Continued:					
Clays:					
China clay or kaolin		194	46,100	281	68,700
Fire clay		(4) r	79 r	(4)	133
Decolorizing earths and fuller's earth		1	100	1	96
Bentonite		7	2,670 r	8	2,460
Other clay		5 r	3,230	8	3,940
Chamotte or dina's earth		(4) r	42 r	(4)	165
Artificially activated clay and activated earth		30 r	34,400 r	27	28,800
Diamond, industrial:					
Diamond stones, natural and miners'	thousand carats	3,220	41,500	1,400	18,700
Powder, dust and grit, natural and synthetic	do.	492,000	75,400	246,000	40,800
Diatomite, siliceous fossil meals	metric tons	2,890	1,140	1,260	1,080
Feldspar and nepheline syenite:					
Feldspar	do.	2,030	646	2,120	646
Nepheline syenite	do.	321,000	35,000	308,000	36,800
Fluorspar:					
Aluminum fluoride	do.	47,600	69,400	18,700	26,800
Cryolite	do.	7,650	8,180	2,830	3,630
Fluorspar	do.	572,000	133,000	475,000	105,000
Hydrofluoric acid	do.	133,000	172,000	114,000	161,000
Garnet, industrial	do.	49,200	11,500	37,900	8,890
Gemstones		XX	20,900,000	XX	13,300,000
Graphite:					
Natural	metric tons	58,300	48,100	33,100	29,700
Electric furnace electrodes	do.	98,100	303,000	50,600	190,000
Gypsum:					
Crude		7,330	93,400	4,220	52,900
Plasters		13	7,240	15	6,800
Boards		306	50,600	236	38,500
Other		XX	43,400	XX	30,300
Iodine:					
Crude	metric tons	6,300	144,000	5,190	133,000
Potassium iodide	do.	564	12,100	259	6,000
Iron oxide pigments:					
Natural	do.	4,700	2,640	1,900	1,070
Synthetic	do.	151,000	161,000	105,000	126,000
Kyanite, andalusite, sillimanite	do.	5,580	1,930	4,880	2,060
Lime		307	39,400	422	53,200
Lithium chemicals:					
Carbonate	metric tons	15,800	70,100	9,250	41,900
Hydroxide	do.	1,160	7,400	932	5,580
Magnesium compounds:					
Compounds, chlorides, hydroxide, peroxide, sulfates	do.	162,000	48,700 r	133,000	38,500
Magnesite, crude and processed:					
Caustic-calcined magnesia	do.	167,000	40,400	126,000	37,700
Dead-burned and fused magnesia	do.	386,000	190,000	151,000	72,200
Other magnesia	do.	13,900	14,000	8,740	8,750
Crude	do.	15,800	5,720	6,270	3,830

See footnotes at end of table.

TABLE 8—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS[1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2008		2009	
		Quantity	Value[3]	Quantity	Value[3]
Industrial minerals—Continued:					
Mica:					
Scrap and flake:					
Powder	metric tons	23,400	12,300	16,900	9,540
Waste	do.	3,560	1,470	2,990	1,670
Sheet:					
Unworked	do.	130	465	23	142
Worked	do.	1,750	17,900	1,020	14,400
Nitrogen, major compounds, gross weight		21,500	8,810,000	12,600	3,570,000
Peat moss	metric tons	936,000	228,000	906,000	230,000
Perlite, processed crude	do.	187,000	24,700	153,000	15,900
Phosphate rock and phosphatic materials		4,860	692,000	92	348,000
Potash, chloride, sulfate, nitrate, sodium nitrate mixtures	metric tons	9,560,000	3,080,000 [r]	3,670,000	1,780,000
Pumice:					
Crude or unmanufactured	do.	65,000	2,890	26,000	784
Wholly or partially manufactured	do.	436	1,890	258	832
Salt		13,800	282,000	14,700	337,000
Sand and gravel:					
Construction		5,430	114,000 [7]	2,980	66,100 [7]
Industrial		355	23,500	95	8,080
Silica, special stone products		NA	9,320 [r]	NA	8,320
Soda ash		13	3,820	6	2,350
Stone:					
Crushed, chips, calcium carbonate fines, excludes precipitated carbonates		20,900	232,000 [7]	12,200	174,000 [7]
Dimension		XX	2,150,000	XX	1,350,000
Strontium:					
Carbonate	kilograms	12,700,000	8,560	7,820,000	5,090
Celestite	do.	4,620,000	295	14,600,000	690
Metal	do.	170,000	791	70,100	564
Nitrate	do.	3,890,000	4,430	2,770,000	2,770
Oxide, hydroxide, peroxide	do.	106,000	152	6,720	51
Sulfur:					
Elemental		3,000 [e]	753,000	1,700 [e]	54,100
Sulfuric acid, 100% H_2SO_4	metric tons	5,180,000 [r]	468,000 [r]	1,260,000	146,000
Talc, unmanufactured		193	56,400	120	47,900
Vermiculite[e]		73	12,600	39	7,100
Wollastonite[e]	metric tons	5,000	650	4,000	530
Zeolites[e]	do.	200	42	300	64
Total		XX	41,300,000 [r]	XX	23,800,000
Grand total		XX	107,000,000	XX	65,000,000

[e] Estimated. [r] Revised. do. Ditto. NA Not available. XX Not applicable. -- Zero.

[1] Table includes data available through July 26, 2011.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Customs value unless otherwise specified.

[4] Less than ½ unit.

[5] Not specifically provided for.

[6] Excludes Puerto Rico.

[7] Cost, insurance, and freight value.

TABLE 9

WORLD AND U.S. PRODUCTION OF SELECTED NONFUEL MINERAL COMMODITIES[1]

(Thousand metric tons unless otherwise specified)

Mineral or product		World total					United States	
	2005	2006	2007	2008	2009	2009	Percentage of world total
Metals:							
Alumina	65,000 r	72,300 r	77,700 r	82,600 r	76,400	3,060	4.0
Aluminum[2]	33,900 r	38,000 r	39,600 r	36,900 r	40,800	1,730	4.2
Antimony metric tons	172,000	173,000 r	180,000	182,000 r	155,000	--	--
Arsenic trioxide[3] do.	60,000	61,100	55,700	53,600 r	54,400	--	--
Bauxite[3, 4, 5]	178,000 r	193,000 r	204,000 r	211,000 r	199,000	NA	NA
Beryl[3] metric tons	3,450	4,360	4,360	4,940 r	3,590	3,030	84.3
Bismuth, refinery do.	13,900	15,300	15,500	15,400	15,100	--	--
Cadmium, refinery do.	20,100	19,900	19,400	20,100 r	18,800	633	3.4
Chromite[3]	6,900 r	7,300 r	8,400 r	8,100 r	7,000	--	--
Cobalt, Co content:							
Mine metric tons	65,200 r	68,900 r	71,500 r	76,300 r	72,300	--	--
Refinery do.	54,100	53,800	53,300	57,200 r	59,800	--	--
Copper:							
Mine	15,000	15,100 r	15,500	15,400	15,900	1,180	7.4
Smelter	13,500 r	14,100 r	14,300	14,700	14,500	597	4.1
Refinery	16,600 r	17,300	17,900 r	18,300 r	18,400	1,160	6.3
Gold kilograms	2,470,000	2,370,000	2,360,000 r	2,290,000 r	2,450,000	223,000	9.1
Indium, refinery do.	607,000 r	636,000 r	620,000 r	601,000 r	546,000	--	--
Iron ore[3]	1,550,000	1,840,000	2,040,000	2,210,000 r	2,240,000	26,700	1.2
Iron and steel:							
Direct-reduced iron[2]	56,300	58,800 r	64,700 r	66,500 r	64,500	--	--
Pig iron[2]	802,000	881,000	955,000 r	931,000 r	935,000	19,000	2.0
Raw steel	1,140,000	1,250,000	1,350,000	1,330,000	1,240,000	59,400	4.8
Lead:							
Mine, Pb content metric tons	3,470,000 r	3,590,000 r	3,690,000 r	3,860,000 r	3,860,000	406,000	10.5
Refinery do.	7,660,000 r	7,970,000 r	8,250,000 r	8,700,000 r	8,820,000	1,210,000	13.8
Magnesium[5]	622	675	751	670 r	608	W	NA
Manganese ore[3]	31,000	33,200 r	35,100 r	38,100 r	33,600	--	--
Mercury[5] metric tons	1,520	1,150	1,200	1,320	1,920	NA [6]	NA
Molybdenum, Mo content do.	186,000 r	186,000	213,000	218,000 r	221,000	47,800 [7]	21.6
Nickel, Ni content:							
Mine do.	1,460,000 r	1,570,000 r	1,670,000 r	1,560,000 r	1,400,000	--	--
Refinery do.	1,310,000 r	1,350,000	1,440,000 r	1,400,000 r	1,380,000	--	--
Niobium (columbium)-tantalum concentrates[3] do.	264,000 r	223,000 r	263,000 r	264,000 r	263,000	--	--
Platinum-group metals kilograms	504,000 r	514,000	507,000 r	460,000 r	445,000	16,500	3.7
Rhenium do.	47,300 r	46,700	47,500 r	54,900 r	46,200	5,580	12.1
Selenium[2, 5] do.	2,020,000 r	2,160,000 r	2,250,000 r	2,220,000 r	2,280,000	W	NA
Silver metric tons	20,800	20,300	21,000 r	21,300	21,800	1,250	5.7
Tellurium[2, 5] kilograms	112,000 r	116,000 r	124,000 r	121,000 r	118,000	W	NA
Tin:							
Mine metric tons	296,000 r	291,000 r	301,000 r	257,000 r	260,000	--	--
Smelter[8] do.	344,000	339,000	346,000 r	322,000 r	342,000	11,100	3.2
Tungsten, W content do.	59,500 r	56,000 r	54,100	62,200 r	61,300	W	NA
Vanadium do.	56,400	57,900	58,500	56,400 r	54,100	--	--
Zinc:							
Mine, Zn content of concentrate and direct shipping ore	10,000 r	10,300	11,000	11,600 r	11,200	736	6.6
Smelter	10,300 r	10,800 r	11,400 r	11,700 r	11,400	203	1.8

See footnotes at end of table.

TABLE 9—Continued

WORLD AND U.S. PRODUCTION OF SELECTED NONFUEL MINERAL COMMODITIES[1]

(Thousand metric tons unless otherwise specified)

Mineral or product		World total					United States	
		2005	2006	2007	2008	2009	2009	Percentage of world total
Industrial minerals:								
Asbestos	metric tons	2,210,000 [r]	2,150,000 [r]	2,240,000 [r]	2,150,000 [r]	2,070,000	--	--
Barite	do.	7,870,000 [r]	7,960,000 [r]	7,730,000 [r]	8,200,000 [r]	6,130,000	383,000 [9]	6.3
Boron minerals	do.	4,950,000	3,760,000	4,200,000 [r]	3,850,000 [r]	3,510,000	W	NA
Bromine	do.	654,000 [r]	669,000 [r]	408,000 [r]	412,000 [r]	375,000	W [9]	NA
Celesite	do.	509,000	524,000 [r]	518,000 [r]	656,000 [r]	402,000	--	--
Cement, hydraulic		2,350,000	2,610,000	2,810,000	2,850,000 [r]	3,040,000	64,900 [10]	2.1
Clays:								
Bentonite		11,200 [r]	11,400 [r]	11,300 [r]	11,600 [r]	9,700	3,650	37.7
Fuller's earth	metric tons	3,980,000	3,700,000	3,720,000	3,510,000 [r]	3,210,000	2,010,000	62.6
Kaolin		39,100 [r]	38,900 [r]	36,700 [r]	36,100	33,000	5,290	16.0
Diamond:								
Natural	thousand carats	183,000	175,000 [r]	170,000 [r]	154,000 [r]	129,000	--	--
Synthetic	do.	4,220,000 [r]	4,320,000 [r]	4,420,000 [r]	4,420,000 [r]	4,380,000	91,000	2.1
Diatomite	metric tons	1,960,000 [r]	2,150,000 [r]	1,970,000 [r]	2,070,000 [r]	1,870,000	575,000 [9]	30.8
Feldspar		16,800 [r]	20,500	21,500 [r]	22,800 [r]	19,800	550	2.8
Fluorspar	metric tons	5,360,000 [r]	5,660,000 [r]	5,720,000 [r]	5,990,000 [r]	5,460,000	--	--
Graphite, natural	do.	1,030,000	1,020,000	1,110,000 [r]	1,120,000	1,090,000	--	--
Gypsum		147,000 [r]	160,000 [r]	166,000 [r]	155,000 [r]	149,000	10,400	7.0
Iodine, crude	metric tons	26,500	26,700	26,300	26,500	28,500	W	NA
Iron oxide pigments	do.	1,070,000 [r]	1,020,000 [r]	1,070,000 [r]	1,050,000 [r]	890,000	W	NA
Kyanite and related minerals	do.	462,000 [r]	456,000 [r]	516,000	448,000 [r]	416,000	111,000 [11]	26.7
Lime		270,000 [r]	284,000 [r]	296,000 [r]	307,000 [r]	299,000	15,800 [9, 10]	5.3
Lithium	metric tons	344,000	394,000	381,000	387,000 [r]	301,000	W	NA
Magnesite, crude[5]		15,600 [r]	15,600 [r]	16,700 [r]	18,400 [r]	19,000	W	NA
Mica, including scrap and flake[12]	metric tons	359,000 [r]	385,000 [r]	387,000 [r]	379,000 [r]	315,000	50,100	15.9
Monazite[13]	do.	6,280 [r]	6,850 [r]	6,860 [r]	6,900	6,800	--	--
Nitrogen, N content of ammonia		122,000 [r]	126,000 [r]	131,000 [r]	130,000 [r]	130,000	7,700 [14]	5.9
Peat		26,000 [r]	25,700 [r]	25,600 [r]	24,900 [r]	25,000	609 [15]	2.4
Perlite	metric tons	1,790,000	1,800,000 [r]	1,750,000	1,790,000	1,650,000	348,000 [9]	21.1
Phosphate rock[3]		152,000 [r]	151,000 [r]	160,000 [r]	165,000 [r]	166,000	26,400	15.9
Potash, K_2O equivalent		33,800	30,400 [r]	35,700 [r]	34,500 [r]	20,800	720	3.4
Pumice		18,300 [r]	20,400 [r]	20,700	18,900 [r]	17,200	410 [9]	2.4
Rare earths	metric tons	122,000	137,000	124,000	128,000 [r]	132,000	--	--
Salt		249,000 [r]	259,000 [r]	259,000 [r]	264,000 [r]	276,000	46,100 [10]	16.7
Sand and gravel, industrial, silica		113,000 [r]	116,000 [r]	120,000 [r]	122,000 [r]	106,000	24,600 [9]	23.2
Soda ash, natural and manufactured		41,000 [r]	42,600	44,900	45,600 [r]	44,100	9,310 [16]	21.1
Sulfur, all forms		68,200 [r]	67,500 [r]	68,200 [r]	68,700 [r]	67,500	8,940	13.2
Talc and pyrophyllite[17]	metric tons	7,950,000 [r]	7,770,000 [r]	7,700,000 [r]	7,580,000 [r]	7,430,000	511,000	6.9
Titanium concentrates:[3]								
Ilmenite and leucoxene	metric tons	6,050,000	6,850,000 [r]	7,120,000 [r]	6,870,000 [r]	6,180,000	300,000 [18]	4.9
Rutile[5]	do.	377,000 [r]	515,000 [r]	604,000 [r]	628,000 [r]	577,000	(19)	NA
Vermiculite	do.	521,000	513,000	502,000 [r]	517,000 [r]	505,000	100,000 [20]	19.8
Zirconium	do.	1,060,000	1,210,000	1,380,000	1,270,000 [r]	1,160,000	W	NA

[r] Revised. do. Ditto. NA Not available. W Withheld to avoid disclosing company proprietary data; not included in "World total." -- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Primary.

[3] Gross weight.

[4] Individual country figures that are included in the world total represent dried bauxite equivalent of crude ore, but for some countries available data are insufficient to permit this adjustment.

[5] "World total" for years listed does not include U.S. production.

[6] U.S. production of mercury is byproduct only.

[7] Listed in Molybdenum chapter (table 1) as production.

[8] Includes tin content of alloys made directly from ore.

TABLE 9—Continued
WORLD AND U.S. PRODUCTION OF SELECTED NONFUEL MINERAL COMMODITIES[1]

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[9] Quantity sold or used by producers.

[10] Includes Puerto Rico.

[11] Includes synthetic mullite.

[12] Excludes, if any, U.S. production of low-quality sericite and sheet mica.

[13] Monazite totals are rounded to two significant digits.

[14] Synthetic anhydrous ammonia; excludes coke oven byproduct ammonia.

[15] Horticultural use.

[16] U.S. production is natural only.

[17] Data for the United States exclude proprietary pyrophyllite production.

[18] Includes rutile to avoid disclosing company proprietary data. Rounded to one significant digit.

[19] Included with ilmenite to avoid disclosing company proprietary data; not included in "Total."

[20] Rounded to one significant digit.

MINING AND QUARRYING TRENDS

By Mary E. Ewell

Domestic survey data were prepared by the author and the statistical assistants who have responsibility for the mineral commodities covered in this report.

The mining and quarrying trends shown in this report were calculated from nonfuel mineral data reported to the U.S. Geological Survey (USGS) by mining and quarrying companies operating in the United States. The data for 2009 were reported on the "Mine, Development, and Mineral Exploration Supplement" statistical survey conducted by the USGS and on the production surveys for some more widely produced nonfuel mineral commodities, such as sand and gravel. Additional data for 2009 were derived from annual USGS production and consumption surveys of nonfuel mineral producers; these surveys accounted for 58 nonfuel mineral commodities produced in the United States. Nonfuel minerals do not include coal, petroleum coke, and related products.

The data in the following tables are reported according to the primary or principal product of a mine or operation; a product of lesser value is considered to be a byproduct. The primary product is the product with the highest total value for the year. In some instances, the values of two products at the same operation are so similar that the products are coproducts.

Total domestic mining and waste removal for nonfuel mineral materials production amounted to 5.0 billion metric tons (Gt) in 2009, a decrease of 10% compared with the revised figure for 2008 (table 1). These materials included 3.6 Gt of crude ore mined or quarried and 1.4 Gt of mine ore and waste from development operations. Of the nonfuel mineral materials (ore and waste) removed, 49% was for the production of industrial minerals, and 51% was for the production of metals. Overall, 97% of nonfuel mineral materials was mined and quarried using surface methods, and 3% was mined underground.

Total surface mining, quarrying, and waste removal for industrial minerals production amounted to 2.3 Gt, 15% lower than the revised 2008 total. Crude ore mined at these surface operations was 2.1 Gt, and 210 million metric tons (Mt) was waste removed, including ore and waste from development operations. Underground mining for industrial minerals was only 123 Mt, nearly all of which was crude ore.

Total surface mining and waste removal to obtain metal ores amounted to 2.5 Gt, 5% lower than the revised 2008 total. Of the 2.5 Gt, 1.4 Gt was crude ore mined, and 1.1 Gt was ore and waste from development operations. Underground mining of metal ores and waste removal amounted to 15 Mt, of which 90% was crude ore.

The leading States in which mining for nonfuel mineral materials took place were, in descending order of total material handled, Nevada, Arizona, Texas, Florida, Minnesota, California, Pennsylvania, Utah, Missouri, and Illinois (table 2). These 10 States accounted for 59% of the tonnage removed in the production of nonfuel mineral materials mined in the United States. Nearly all nonfuel mine production in these States was from surface operations.

TABLE 1
MATERIAL HANDLED AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES, BY TYPE[1]

(Million metric tons)

	Surface[2]			Underground[3]			All mines		
Type of ore and year	Crude ore	Waste[4]	Total	Crude ore	Waste[4]	Total	Crude ore	Waste[4]	Total
Metals:									
2005	1,270	1,070	2,340	20	1	21	1,290	1,080	2,360
2006	1,310	1,060 [r]	2,370 [r]	16	3	19	1,330	1,060 [r]	2,390 [r]
2007	1,370 [r]	1,120 [r]	2,500 [r]	19	3	22	1,390 [r]	1,130	2,520 [r]
2008	1,460	1,170 [r]	2,630 [r]	17	4	21	1,480	1,170 [r]	2,650 [r]
2009	1,360	1,140	2,500	13	1	15	1,370	1,140	2,520
Industrial minerals:									
2005	3,090	370	3,460	137	1	138	3,230	370	3,600
2006	3,130	266	3,400	129	(5)	129	3,260	267 [r]	3,520
2007	2,900	265	3,170	129	(5)	129	3,030	265	3,290
2008	2,520 [r]	251 [r]	2,770 [r]	150 [r]	(5)	150 [r]	2,670 [r]	252 [r]	2,920 [r]
2009	2,130	210	2,340	123	1	123	2,260	210	2,470
All mineral commodities:									
2005	4,360	1,440	5,800 [r]	157	2	159	4,520	1,450	5,960
2006	4,440	1,330 [r]	5,770 [r]	145	3	148	4,590	1,330 [r]	5,920 [r]
2007	4,270 [r]	1,390 [r]	5,660 [r]	148	3	151	4,420 [r]	1,390 [r]	5,810 [r]
2008	3,970 [r]	1,420 [r]	5,390 [r]	168 [r]	4	172 [r]	4,140 [r]	1,420 [r]	5,570 [r]
2009	3,490	1,350	4,840	136	2	138	3,630	1,350	4,980

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes materials from wells, ponds, and pumping operations.

[3] Includes solution mining.

[4] Includes ore and waste from development operations.

[5] Less than ½ unit.

TABLE 2

MATERIAL HANDLED AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 2009, BY COMMODITY AND STATE[1]

Commodity or State	Number of mines[2]	Surface[3] Crude ore (thousand metric tons)	Surface[3] Waste[5] (thousand metric tons)	Surface[3] Total (thousand metric tons)	Underground[4] Crude ore (thousand metric tons)	Underground[4] Waste[5] (thousand metric tons)	Underground[4] Total (thousand metric tons)	All mines Crude ore (thousand metric tons)	All mines Waste[5] (thousand metric tons)	All mines Total (thousand metric tons)
Commodity:										
Metal ore:										
Copper[6]	18	594,000	213,000	807,000	--	--	--	594,000	213,000	807,000
Gold	46	273,000	683,000	955,000	5,220	W	5,220	278,000	683,000	961,000
Iron	12	80,800	73,600	154,000	--	--	--	80,800	73,600	154,000
Other[7]	25	411,000	174,000	585,000	8,110	1,410	9,520	420,000	175,000	595,000
Total	101	1,360,000	1,140,000	2,500,000	13,300	1,410	14,700	1,370,000	1,140,000	2,520,000
Industrial minerals:										
Clays	577	24,500	19,700	44,200	--	--	--	24,500	19,700	44,200
Gypsum	31	11,400	2,190	13,600	1,100	--	1,100	12,500	--	12,500
Feldspar[8]	12	554	--	554	--	--	--	554	--	554
Phosphate rock	12	107,000	W	107,000[9]	--	--	--	107,000	W	107,000[9]
Pumice[10]	17	410	--	410	--	--	--	410	--	410
Salt	60	7,100	--	7,100	36,000	--	36,000	43,100	--	43,100
Sand and gravel:										
Construction	6,438	840,000	--	840,000	--	--	--	840,000	--	840,000
Industrial	119	25,000	--	25,000	W	--	W	25,000[11]	--	25,000[11]
Soda ash	6	--	--	--	9,310	--	9,310	9,310	--	9,310
Stone:										
Crushed	3,968	1,100,000	81,100	1,180,000	65,100	501	65,600	1,170,000	81,600	1,250,000
Dimension	239	1,620	W	1,620[9]	W	--	W	1,620[11]	W	1,620[9,11]
Talc	8	511	W	511[9]	--	--	--	511	W	511[9]
Other[12]	162	13,900	107,000	121,000	11,500	--	11,500	25,300	109,000	134,000
Total	11,649	2,130,000	210,000	2,340,000	123,000	501	123,000	2,260,000	210,000	2,470,000
Grand total	11,750	3,490,000	1,350,000	4,840,000	136,000	1,910	138,000	3,630,000	1,350,000	4,980,000
State:										
Alabama	177	46,900	3,960	50,900	W	--	W	46,900[11]	3,960	50,900[11]
Alaska	102	35,300	W	35,300[9]	W	--	W	35,300[11]	W	35,300[9,11]
Arizona	339	538,000	W	538,000[9]	W	W	W	538,000[11]	W	538,000[9,11]
Arkansas	175	40,000	3,910	43,900	W	--	W	40,000[11]	3,910	43,900[11]
California	558	144,000	W	144,000[9]	W	W	W	144,000[11]	W	144,000[9,11]
Colorado	335	56,700	W	56,700[9]	W	--	W	56,700[11]	W	56,700[9,11]
Connecticut	113	13,600	657	14,300	--	--	--	13,600	657	14,300
Delaware	11	2,420	W	2,420[9]	--	--	--	2,420	W	2,420[9]
Florida	170	154,000	W	154,000[9]	--	--	--	154,000	W	154,000[9]
Georgia	188	55,700	7,080	62,800	W	W	W	55,700[11]	7,080[11]	62,800[11]
Hawaii	54	6,950	466	7,420	--	--	--	6,950	466	7,420
Idaho	165	27,200	W	27,200[9]	W	W	W	27,200[11]	W	27,200[9,11]
Illinois	253	68,500	3,480	72,000	10,400	73	10,500	78,900	3,550	82,500
Indiana	243	56,300	3,470	59,800	5,380	42	5,420	61,700	3,510	65,200

See footnotes at end of table.

TABLE 2—Continued

MATERIAL HANDLED AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 2009, BY COMMODITY AND STATE[1]

		Surface[3]			Underground[4]			All mines		
Commodity or State	Number of mines[2]	Crude ore (thousand metric tons)	Waste[5] (thousand metric tons)	Total (thousand metric tons)	Crude ore (thousand metric tons)	Waste[5] (thousand metric tons)	Total (thousand metric tons)	Crude ore (thousand metric tons)	Waste[5] (thousand metric tons)	Total (thousand metric tons)
State—Continued:										
Iowa	387	41,500	2,450	44,000	5,420	35	5,450	46,900	2,490	49,400
Kansas	301	26,600	1,700	28,300	2,720	3	2,730	29,300	1,710	31,000
Kentucky	118	35,900	2,640	38,500	14,600	111	14,700	50,500	2,750	53,200
Louisiana	142	29,600	835	30,400	13,500	--	13,500	43,100	835	43,900
Maine	179	12,600	335	12,900	--	--	--	12,600	335	12,900
Maryland[13]	83	30,200	1,710	31,900	W	W	W	30,200 [11]	1,710 [11]	31,900 [11]
Massachusetts	141	17,900	703	18,600	--	--	--	17,900	703	18,600
Michigan	431	78,800	W	78,800 [9]	1,800	--	1,800	80,600	W	80,600 [9]
Minnesota	441	97,900	48,800	147,000	--	--	--	97,900	48,800	147,000
Mississippi	108	16,200	673	16,900	--	--	--	16,200	673	16,900
Missouri	338	70,300	5,470	75,700	14,600	1,140	15,800	84,900	6,610	91,500
Montana	226	55,200	W	55,200 [9]	2,280	218	2,500	57,500	218	57,700 [9]
Nebraska	186	15,400	247	15,700	W	W	W	15,400 [11]	247 [11]	15,700 [11]
Nevada	325	620,000	770,000	1,390,000	W	W	W	620,000 [11]	770,000 [11]	1,390,000 [11]
New Hampshire	121	10,900	338	11,200	--	--	--	10,900	338	11,200
New Jersey	83	23,900	948	24,800	--	--	--	23,900	948	24,800
New Mexico	211	48,200	590	48,800	W	--	W	48,200 [11]	590	48,800 [11]
New York	567	66,900	3,470	70,300	7,160	W	7,160 [11]	74,000	3,470 [11]	77,500 [11]
North Carolina	260	56,200	6,410	62,600	--	--	--	56,200	6,410	62,600
North Dakota	149	14,600	W	14,600 [9]	--	--	--	14,600	W	14,600 [9]
Ohio	320	64,700	3,420	68,100	6,320	W	6,320 [11]	71,000	3,420 [11]	74,400 [11]
Oklahoma	177	48,300	3,300	51,600	W	W	W	48,300 [11]	3,300 [11]	51,600 [11]
Oregon	312	27,900	1,210	29,100	--	--	--	27,900	1,210	29,100
Pennsylvania	389	84,000	6,110	90,100	8,080	69	8,150	92,000	6,180	98,200
Rhode Island	22	3,260	105	3,360	--	--	--	3,260	105	3,360
South Carolina	110	24,600	1,660	26,300	--	--	--	24,600	1,660	26,300
South Dakota	146	25,900	W	25,900 [9]	--	--	--	25,900	W	25,900 [9]
Tennessee	192	42,000	3,390	45,400	2,560	W	2,560 [11]	44,500	3,390 [11]	47,900 [11]
Texas	587	181,000	10,400	192,000	8,270	W	8,270 [11]	190,000	10,400 [11]	200,000 [11]
Utah	291	94,800	W	94,800 [9]	W	--	W	94,800 [11]	W	94,800 [9, 11]
Vermont	144	9,650	459	10,100	--	--	--	9,650	459	10,100
Virginia	175	51,700	3,640	55,300	W	W	W	51,700 [11]	3,640 [11]	55,300 [11]
Washington	363	44,500	1,170	45,700	W	W	W	44,500 [11]	1,170 [11]	45,700 [11]
West Virginia	51	14,900	822	15,700	W	W	W	14,900 [11]	822 [11]	15,700 [11]
Wisconsin	566	53,600	1,860	55,500	W	--	W	53,600 [11]	1,860	55,500 [11]
Wyoming	225	40,100	4,100	44,200	8,530	--	8,530	48,600	4,100	52,700
Undistributed[14]	--	65,800	441,000	506,000	24,600	215	24,800	90,500	441,000	531,000
Total	11,750	3,490,000	1,350,000	4,840,000	136,000	1,910	138,000	3,630,000	1,350,000	4,980,000

See footnotes at end of table.

TABLE 2—Continued
MATERIAL HANDLED AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 2009, BY COMMODITY AND STATE[1]

W Withheld to avoid disclosing company proprietary data; included with "Other" or "Undistributed." -- Zero.

[1] Data are rounded to no more than three significant digits except "number of mines"; may not add to totals shown.

[2] Includes quarries and other mineral operations.

[3] Includes materials from wells, ponds, and pumping operations.

[4] Includes solution mining.

[5] Includes ore and waste from development operations.

[6] Includes copper-molybdenum. With increased adoption of leaching technology, there may be less distinction between ore and waste. Significant tonnages of low-grade material, formerly classified as waste, are now considered to be low-grade leachable ore by some companies, resulting in a large shift in the ore-to-waste ratios and a reduction in ore value; see data in table 3.

[7] Includes beryllium, gold-silver, lead, magnesium metal, molybdenum, platinum and palladium, silver, titanium, uranium, zinc, zinc-lead, and zinc-silver.

[8] Includes aplite.

[9] Excludes waste from mining operations and ore and waste from development operations.

[10] Excludes volcanic cinder and scoria; included with "Crushed stone."

[11] Excludes materials from underground operations.

[12] Includes abrasives, barite, boron minerals, bromine, diatomite, garnet, greensand marl, iodine, iron oxide pigments, kyanite, lithium minerals, magnesite, magnesium compounds, mica, olivine, perlite, potash, tripoli, vermiculite, wollastonite, zeolites, and industrial minerals indicated by symbol W.

[13] Includes data reported in Washington, DC.

[14] Includes material from States indicated by symbol W.

TABLE 3
VALUE OF PRINCIPAL MINERAL PRODUCTS AND BYPRODUCTS OF SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 2009[1]

(Dollars per metric ton)

	Surface			Underground			All mines		
Commodity	Principal mineral product	Byproduct	Total	Principal mineral product	Byproduct	Total	Principal mineral product	Byproduct	Total
Metal ore:									
Gold	26.68	W	26.68[2]	W	W	W	26.68[3]	W	26.68[2, 3]
Copper[4]	5.32	W	5.32[2]	--	--	--	5.32	W	5.32[2]
Iron	92.76[5]	--	92.76[5]	--	--	--	92.76[5]	--	92.76[5]
Average, metals[6]	15.40	W	15.40[2]	210.93	27.57	238.50	18.32	3.19	21.51
Industrial minerals:									
Clays	54.28	--	54.28	W	--	W	54.28	--	54.28[3]
Feldspar[7]	64.32	--	64.32	--	--	--	64.32	--	64.32
Gypsum	7.30	--	7.30	W	--	W	7.30	--	7.30[3]
Phosphate rock	127.19[8]	--	127.19[8]	--	--	--	127.19	--	127.19
Pumice[9]	29.97	--	29.97	--	--	--	29.97	--	29.97
Salt	W	--	W	36.72[5]	--	36.72[5]	36.72[5, 10]	--	36.72[5, 10]
Sand and gravel:									
Construction	7.56	--	7.56	--	--	--	7.56	--	7.56
Industrial	31.90	--	31.90	W	--	W	31.90[3]	--	31.90[3]
Soda ash	--	--	--	143.17	W	143.17[2]	143.17	--	143.17
Stone:									
Crushed	9.70	--	9.70	9.70	--	9.70	9.70	--	9.70
Dimension	202.61	--	202.61	W	--	W	202.61[3]	--	202.61[3]
Talc	28.63	--	28.63	--	--	--	28.63	--	28.63
Average, industrial minerals[11]	11.65	0.04	11.69	27.75	5.92	33.67	12.54	0.36	12.90
Average, industrial minerals, excluding sand and gravel and stone[11]	41.62	0.3	41.92	51.24	13.71	64.95	44.02	3.64	47.66
Average, metals and industrial minerals[6, 11]	12.78	0.88	13.66	46.24	8.11	54.35	14.23	1.19	15.42
Average, metals and industrial minerals, excluding sand and gravel and stone[6, 11]	19.32	2.45	21.77	84.20	16.57	100.77	23.13	3.28	26.41

W Withheld to avoid disclosing company proprietary data; included in appropriate "Average." -- Zero.

[1] Values calculated from unrounded data; may not add to totals shown because of independent rounding.

[2] Value of principal mineral product only.

[3] Value of products at surface operations only.

[4] Includes copper-molybdenum. With increased adoption of leaching technology, there may be less distinction between ore and waste. Significant tonnages of low-grade material, formerly classified as waste, are now considered to be low-grade leachable ore by some companies, resulting in a large shift in the ore-to-waste ratios and a reduction in ore value.

[5] Average value at mines only.

[6] Includes beryllium, gold-silver, lead, magnesium metal, molybdenum, platinum and palladium, silver, titanium, uranium, zinc, zinc-lead, zinc-silver, and metals indicated by symbol W.

[7] Includes aplite.

[8] Average value based on the sold or used values.

[9] Excludes volcanic cinder and scoria; included with "Crushed stone."

[10] Value of products at underground operations only.

[11] Includes values of abrasives, barite, boron minerals, bromine, diatomite, garnet, greensand marl, iodine, iron oxide pigments, kyanite, lithium minerals, magnesite, magnesium compounds, mica, olivine, perlite, potash, tripoli, vermiculite, wollastonite, zeolites, and industrial minerals indicated by symbol W.

TABLE 4
TWENTY-FIVE LEADING METAL AND INDUSTRIAL MINERAL MINES AND QUARRIES IN THE UNITED STATES IN 2009, IN ORDER OF OUTPUT OF CRUDE ORE[1]

Name of mine, quarry or operation[2]	State	Operator	Commodity	Mining method
Metal:				
Eastern Nevada operations[3]	Nevada	Newmont Mining Corp.	Gold	Open pit and underground.
Morenci	Arizona	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum	Open pit.
Goldstrike[4]	Nevada	Barrick Gold Corp.	Gold	Open pit and underground.
Cortez	do.	do.	do.	Open pit.
Bagdad	Arizona	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum	Do.
Ray	do.	ASARCO LLC	Copper	Do.
Safford	do.	Freeport-McMoRan Copper & Gold Inc.	do.	Do.
Sierrita	do.	do.	Copper-molybdenum	Do.
Smoky Valley Common Operation	Nevada	Kinross Gold Corp.	Gold	Do.
Mission Complex	Arizona	ASARCO LLC	Copper-molybdenum	Do.
Bingham Canyon	Utah	Kennecott Utah Copper Corp.	do.	Open pit.
Ruby Hill	Nevada	Barrick Gold Corp.	Gold	Do.
Tyrone	New Mexico	Freeport-McMoRan Copper & Gold Inc.	Copper	Do.
Minntac	Minnesota	United States Steel Corp.	Iron ore	Do.
Bald Mountain	Nevada	Barrick Gold Corp.	Gold	Do.
Golden Sunlight	Montana	do.	do.	Do.
Fort Knox	Alaska	Kinross Gold Corp.	do.	Do.
Marigold	Nevada	Goldcorp Inc.	do.	Do.
Cresson	Colorado	AngloGold Ashanti Ltd.	do.	Do.
Continental Pit	Montana	Montana Resources	Copper-molybdenum	Do.
Robinson	Nevada	Quadra Mining Ltd.	do.	Do.
Tilden	Michigan	Cliffs Natural Resources Inc.	Iron ore	Do.
Mesquite	California	New Gold Inc.	Gold	Do.
United Taconite	Minnesota	Cliffs Natural Resources Inc.	Iron ore	Do.
Northshore	do.	do.	do.	Do.
Industrial mineral:				
Florida mines (five)	Florida	The Mosaic Co.	Phosphate rock	Do.
South Pasture	do.	CF Industries, Inc.	do.	Do.
Swift Creek	do.	PCS Phosphate Co., Inc.	do.	Do.
Beckmann	Texas	Martin Marietta Aggregates	Stone, crushed	Do.
Aurora	North Carolina	PCS Phosphate Co., Inc.	Phosphate rock	Do.
Peerless Mine	Missouri	Mississippi Lime Co.	Stone, crushed	Underground.
Perch Hill 74	Texas	Lehigh Hanson, Inc.	do.	Quarry.
Ste. Genevieve Quarry	Missouri	Tower Rock Stone Co.	do.	Do.
Balcones Plant	Texas	CEMEX S.A.B. de C.V.	do.	Do.
White Rock	Florida	Vecellio & Grogan, Inc.	do.	Do.
South Hansen Pit	Utah	Geneva Rock Products, Inc.	Sand and gravel, construction	Open pit.
Georgetown	Texas	Texas Crushed Stone Co., Inc.	Stone, crushed	Quarry.
McCook 378	Illinois	Vulcan Materials Co.	do.	Do.
Three Rivers Quarry	Kentucky	Martin Marietta Aggregates	do.	Do.
Plant 1	West Virginia	Letart Corp.	Sand and gravel, construction	Open pit.
Ogden	Utah	Great Salt Lake Minerals Corp.	Magnesium compounds	Well and pumping.
F.E.C. Quarry	Florida	CEMEX S.A.B. de C.V.	Stone, crushed	Quarry.
Brooksville	do.	do.	do.	Do.
Macon Quarry	Georgia	Ready Mix USA Holding Co.	do.	Do.
Pennsuco Quarry	Florida	Titan America LLC	do.	Do.
Hampton Corners	New York	American Rock Salt Co.	Salt	Solution.
Clinton PI	do.	Tilcon New York Inc.	Stone, crushed	Quarry.
Thornton Quarry	Illinois	Lehigh Hanson, Inc.	do.	Do.
Freeport	Texas	Dow Chemical Co.	Salt	Solution.
Cushenbury Plant	California	Mitsubishi Cement Corp.	Stone, crushed	Quarry.

Do., do. Ditto.

List includes private-sector operations only; excludes U.S. Bureau of Land Management and U.S. Forest Service operations.

Where data are not reported for individual mining operations, ranking is on the basis of production as reported for a group of operations.

Includes Carlin Mines complex, Carlin East Mine, Deep Post Mine, Gold Quarry Mine, Leeville Mine, Midas Mine, Pete Mine, Phoenix Mine, Twin Creeks Mine, and Turquoise Ridge Mine; ore was mined from eight open pits and six underground mines.

Formerly listed as Betze-Post Mine.

TABLE 5
TWENTY-FIVE LEADING METAL AND INDUSTRIAL MINERAL MINES AND QUARRIES IN THE UNITED STATES IN 2009, IN ORDER OF OUTPUT OF TOTAL MATERIAL HANDLED[1]

Name of mine, quarry or operation[2]	State	Operator	Commodity	Mining method
Metal:				
Goldstrike[3]	Nevada	Barrick Gold Corp.	Gold	Open pit and underground.
Eastern Nevada operations[4]	do.	Newmont Mining Corp.	do.	Do.
Cortez	do.	Barrick Gold Corp.	do.	Open pit.
Bingham Canyon	Utah	Kennecott Utah Copper Corp.	Copper-molybdenum	Do.
Morenci	Arizona	Freeport-McMoRan Copper & Gold Inc.	do.	Do.
Smoky Valley Common Operation	Nevada	Kinross Gold Corp.	Gold	Do.
Bagdad	Arizona	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum	Do.
Ray	do.	ASARCO LLC	Copper	Do.
Safford	do.	Freeport-McMoRan Copper & Gold Inc.	do.	Do.
Robinson	Nevada	Quadra Mining Ltd.	Copper-molybdenum	Do.
Ruby Hill	do.	Barrick Gold Corp.	Gold	Do.
Sierrita	Arizona	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum	Do.
Marigold	Nevada	Goldcorp Inc.	Gold	Do.
Mesquite	California	New Gold Inc.	do.	Do.
Cresson	Colorado	AngloGold Ashanti Ltd.	do.	Do.
Mission Complex	Arizona	ASARCO LLC	Copper-molybdenum	Do.
Golden Sunlight	Montana	Barrick Gold Corp.	Gold	Do.
Minntac	Minnesota	United States Steel Corp.	Iron ore	Do.
Fort Knox	Alaska	Kinross Gold Corp.	Gold	Do.
Bald Mountain	Nevada	Barrick Gold Corp.	do.	Do.
Tilden	Michigan	Cliffs Natural Resources Inc.	Iron ore	Do.
Tyrone	New Mexico	Freeport-McMoRan Copper & Gold Inc.	Copper	Do.
United Taconite	Minnesota	Cliffs Natural Resources Inc.	Iron ore	Do.
Carlota	Arizona	Quadra Mining Ltd.	Copper	Do.
Thompson	Idaho	Thompson Creek Metals Co.	Molybdenum	Do.
Industrial mineral:				
Florida mines (five)	Florida	The Mosaic Co.	Phosphate rock	Do.
Boron Mine	California	U.S. Borax Inc.	Boron	Do.
South Pasture	Florida	CF Industries, Inc.	Phosphate rock	Do.
Swift Creek	do.	PCS Phosphate Co., Inc.	do.	Do.
Aurora	North Carolina	do.	do.	Do.
Beckmann	Texas	Martin Marietta Aggregates	Stone, crushed	Quarry.
Peerless Mine	Missouri	Mississippi Lime Co.	do.	Underground.
Perch Hill 74	Texas	Lehigh Hanson, Inc.	do.	Quarry.
Ste. Genevieve Quarry	Missouri	Tower Rock Stone Co.	do.	Do.
Balcones Plant	Texas	CEMEX S.A.B. de C.V.	do.	Do.
White Rock	Florida	Vecellio & Grogan, Inc.	do.	Do.
Georgetown	do.	Texas Crushed Stone Co., Inc.	do.	Do.
McCook 378	Illinois	Vulcan Materials Co.	do.	Do.
Three Rivers Quarry	Kentucky	Martin Marietta Aggregates	do.	Do.
South Hansen Pit	Utah	Geneva Rock Products, Inc.	Sand and gravel, construction	Open pit.
F.E.C. Quarry	Florida	CEMEX S.A.B. de C.V.	Stone, crushed	Quarry.
Brooksville	do.	do.	do.	Do.
Macon Quarry	Georgia	Ready Mix USA Holding Co.	do.	Do.
Plant I	West Virginia	Letart Corp.	Sand and gravel, construction	Open pit.
Pennsuco Quarry	Florida	Titan America LLC	Stone, crushed	Quarry.
Ogden	Utah	Great Salt Lake Minerals Corp.	Magnesium compounds	Well and pumping.
Clinton Pl	New York	Tilcon	Stone, crushed	Quarry.
Thornton Quarry	Illinois	Lehigh Hanson, Inc.	do.	Do.
Cushenbury Plant	California	Mitsubishi Cement Corp.	do.	Do.
Hampton Corners	New York	American Rock Salt Co.	Salt	Solution.

Do., do. Ditto.

[1] List includes private-sector operations only; excludes U.S. Bureau of Land Management and U.S. Forest Service operations.

[2] Where data are not reported for individual mining operations, ranking is on the basis of production as reported for a group of operations.

[3] Formerly listed as Betze-Post Mine.

[4] Includes Carlin Mines complex, Carlin East Mine, Deep Post Mine, Gold Quarry Mine, Leeville Mine, Midas Mine, Pete Mine, Phoenix Mine, Twin Creeks Mine, and Turquoise Ridge Mine; ore was mined from eight open pits and six underground mines.

TABLE 6
MARKETABLE PRODUCT AND ORE TREATED OR SOLD AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 2009, BY SELECTED COMMODITY AND STATE[1]

(Thousand metric tons, unless otherwise specified)

Commodity or State	Marketable product			Ore treated or sold		
	Surface	Underground	Total	Surface	Underground	Total
Commodity:						
Metal ore:						
Copper[2]	1,180	--	1,180	602,000	--	602,000
Gold	(3)	(3)	223,000 [4]	184,000	5,360	189,000
Iron ore, usable	27,600	--	27,600	80,800	--	80,800
Industrial minerals:						
Clays	24,500	--	24,500	24,500	--	24,500
Feldspar[5]	554	--	554	554	--	554
Gypsum	11,400	2,190	13,600	11,400	2,190	13,600
Phosphate rock	26,400	--	26,400	107,000	--	107,000
Pumice[6]	410	--	410	410	--	410
Salt	(7)	43,100	43,100	(8)	46,000	46,000
Sand and gravel:						
Construction	840,000	--	840,000	840,000	--	840,000
Industrial	25,000	(9)	25,000	30,400	(10)	30,400
Soda ash	--	9,310	9,310	--	9,310	9,310
Stone:						
Crushed	1,100,000	65,100	1,170,000	1,100,000	65,100	1,170,000
Dimension	1,620	(9)	1,620	1,620	(10)	1,620
Talc	511	--	511	511	--	511
State:						
Alabama	48,300	(9)	48,300	48,300	(10)	48,300
Alaska	9,900	(9)	9,900	30,200	(10)	30,200
Arizona	50,400	--	50,400	534,000	(10)	534,000
Arkansas	40,600	(9)	40,600	40,600	(10)	40,600
California	124,000	(9)	124,000	146,000	(10)	146,000
Colorado	36,500	(9)	36,500	56,900	(10)	56,900
Connecticut	13,600	--	13,600	13,600	--	13,600
Delaware	2,420	--	2,420	2,420	--	2,420
Florida	155,000	--	155,000	155,000	--	155,000
Georgia	56,500	(9)	56,500	56,500	(10)	56,500
Hawaii	6,950	--	6,950	6,950	--	6,950
Idaho	20,800	(9)	20,800	28,100	(10)	28,100
Illinois	70,000	10,400	80,400	70,000	10,400	80,400
Indiana	56,400	5,380	61,800	56,400	5,380	61,800
Iowa	41,700	5,420	47,200	41,700	5,420	47,200
Kansas	26,600	2,710	29,300	26,600	2,710	29,300
Kentucky	35,900	14,600	50,500	35,900	14,600	50,500
Louisiana	28,700	12,400	41,100	29,700	13,100	42,800
Maine	12,600	--	12,600	12,600	--	12,600
Maryland	30,400	(9)	30,400	30,400	(10)	30,400
Massachusetts	17,900	--	17,900	17,900	--	17,900
Michigan	66,700	(9)	66,700	79,400	(10)	79,400
Minnesota	59,400	--	59,400	99,000	--	99,000
Mississippi	16,500	--	16,500	16,500	--	16,500
Missouri	70,300	10,300	80,700	70,300	10,300	80,700
Montana	13,600	(9)	13,600	34,300	(10)	34,300
Nebraska	19,800	(9)	19,800	19,800	(10)	19,800
Nevada	31,700	(9)	31,700	181,000	(10)	181,000
New Hampshire	11,000	--	11,000	11,000	--	11,000
New Jersey	26,400	--	26,400	26,400	--	26,400
New Mexico	23,000	(9)	23,000	44,800	(10)	44,800
New York	73,100	5,920	79,000	73,100	5,920	79,000
North Carolina	56,200	--	56,200	56,200	--	56,200

See footnotes at end of table.

TABLE 6—Continued

MARKETABLE PRODUCT AND ORE TREATED OR SOLD AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 2009, BY SELECTED COMMODITY AND STATE[1]

(Thousand metric tons, unless otherwise specified)

	Marketable product			Ore treated or sold		
Commodity or State	Surface	Underground	Total	Surface	Underground	Total
State—Continued:						
North Dakota	14,700	--	14,700	14,700	--	14,700
Ohio	65,000	6,280	71,300	65,000	6,280	71,300
Oklahoma	49,000	(9)	49,000	49,000	(10)	49,000
Oregon	28,000	--	28,000	28,000	--	28,000
Pennsylvania	84,300	8,080	92,300	84,300	8,080	92,300
Rhode Island	3,260	--	3,260	3,260	--	3,260
South Carolina	24,700	--	24,700	24,700	--	24,700
South Dakota	15,200	--	15,200	26,200	--	26,200
Tennessee	42,300	2,560	44,800	42,300	2,560	44,800
Texas	181,000	8,060	189,000	181,000	8,270	190,000
Utah	41,300	(9)	41,300	95,200	(10)	95,200
Vermont	9,700	--	9,700	9,700	--	9,700
Virginia	50,400	(9)	50,400	51,500	(10)	51,500
Washington	44,700	(9)	44,700	45,100	(10)	45,100
West Virginia	17,700	(9)	17,700	17,700	(10)	17,700
Wisconsin	54,700	(9)	54,700	54,700	(10)	54,700
Wyoming	40,300	8,530	48,800	40,300	8,530	48,800

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes copper-molybdenum.

[3] Withheld to avoid disclosing company proprietary data; included in "Marketable product, total."

[4] Kilograms.

[5] Includes aplite.

[6] Excludes volcanic cinder and scoria; included with "Crushed stone."

[7] Withheld to avoid disclosing company proprietary data; included in "Marketable product, underground."

[8] Withheld to avoid disclosing company proprietary data; included in "Ore treated or sold, underground."

[9] Withheld to avoid disclosing company proprietary data; included in "Marketable product, surface."

[10] Withheld to avoid disclosing company proprietary data; included in "Ore treated or sold, surface."

TABLE 7
MINING METHODS USED AT SURFACE OPERATIONS IN THE UNITED STATES IN 2009, BY COMMODITY

(Percentage of total material handled)

Commodity	Preceded by drilling and blasting	Not preceded by drilling and blasting[1]
Metal ore:		
Beryllium	100	--
Copper[2]	99	1
Gold[3]	83	17
Iron	93	7
Magnesium metal	--	100
Molybdenum	100	--
Titanium	--	100
Uranium	--	100
Zinc	100	--
Industrial minerals:		
Abrasives	100	--
Barite	46	54
Boron minerals	100	--
Bromine	51	49
Clays	5	95
Diatomite	--	100
Feldspar[4]	100	--
Garnet	38	62
Greensand marl	--	100
Gypsum	100	--
Iodine	--	100
Iron oxide pigments	--	100
Kyanite	100	--
Lithium minerals	--	100
Magnesite	100	--
Magnesium compounds	--	100
Mica, scrap	22	78
Olivine	69	31
Perlite	26	74
Phosphate rock	4	96
Potash	--	100
Pumice[5]	15	85
Salt	--	100
Sand and gravel:		
Construction	--	100
Industrial	--	100
Stone:		
Crushed	100	--
Dimension	--	100
Talc	96	4
Tripoli	88	12
Vermiculite	35	65
Wollastonite	74	26
Zeolites	99	1

-- Zero.

[1] Includes drilling and cutting without blasting, dredging, mechanical excavation and nonfloat washing, and other surface mining methods.

[2] Includes copper-molybdenum.

[3] Includes gold-silver.

[4] Includes aplite.

[5] Excludes volcanic cinder and scoria; included with "Crushed stone."

TABLE 8

EXPLORATION ACTIVITY IN THE UNITED STATES IN 2009, BY METHOD, COMMODITY, AND STATE[1]

(Meters)

Commodity or State	Churn and diamond drilling	Rotary and reverse circulation drilling	Percussion and other drilling and trenching	Grand total
Commodity:				
Gold	237,000	565,000	W	802,000
Lead	22,400	29,500	--	51,900
Silver	4,170	--	W	4,170
Other[2]	23,000	130,000	168,000	321,000
Total	287,000	725,000	168,000	1,180,000
Percentage of grand total	24	62	14	100
State:				
Alaska	18,100	23,500	W	41,600
Missouri	22,400	29,500	--	51,900
Nebraska	--	73,000	--	73,000
Nevada	235,000	540,000	W	775,000
Undistributed[3]	11,100	59,200	168,000	238,000
Total	287,000	725,000	168,000	1,180,000

W Withheld to avoid disclosing company proprietary data; included with "Other" or "Undistributed." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes boron, clay, copper, molybdenum, uranium, zinc, and commodities indicated by symbol W.

[3] Includes Alabama, Arizona, California, Idaho, Montana, South Carolina, Washington, Wyoming, and States indicated by symbol W.

ABRASIVES, MANUFACTURED

By Donald W. Olson

Domestic survey data and tables were prepared by Monica D. Zeigler, statistical assistant.

In 2009, estimated Canadian and United States combined production of regular-grade fused aluminum oxide was 10,000 metric tons (t) with a value estimated to be $1.7 million. The U.S. apparent consumption of fused aluminum oxide was estimated to be 35,900 t. U.S. silicon carbide production was estimated to be 35,000 t with an estimated value of $25.9 million. The U.S. apparent consumption of crude silicon carbide was estimated to be 77,900 t. U.S. production of metallic abrasives was 138,000 t valued at $70.3 million. U.S. shipments of metallic abrasives were 152,000 t, with a value of $89.5 million. The U.S. apparent consumption of metallic abrasives was estimated to be 142,000 t.

This report includes information on the following abrasives manufactured in the United States: aluminum-zirconium oxide, boron carbide, fused aluminum oxide, metallic shot and grit, and silicon carbide. In some cases, United States production data were combined with Canadian output to avoid disclosing company proprietary data and still provide useful data on the overall Canadian–United States market. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using the unrounded data.

Abrasives play an important role in the fashioning and finishing of many products with a wide range of uses. Abrasives are natural or manufactured substances that are used to abrade, clean, etch, grind, polish, scour, or otherwise remove solid material by rubbing action (as in a grinding wheel) or impact (as in pressure blasting). The most important physical properties for abrasives are character of fracture (cleavage), friability, grain shape and size, hardness (scratch hardness), purity (uniformity), and toughness (rigidity). Additional considerations include availability, bonding characteristics, cost, and thermal stability. Manufactured abrasives are made from metals or minerals by heating or chemically treating them to enhance or give them abrasive properties. No single property is paramount for any use (Wellborn, 1996, p. 31, 43).

Manufactured abrasives generally dominate high-grade abrasives markets as opposed to natural abrasives because they have superior physical properties, more uniform quality, and can be tailored to meet users' needs. Consequently, manufactured abrasives typically are characterized by premium prices relative to natural abrasive minerals. Even though manufactured abrasives are usually more expensive, their durability and efficiency have proven to be more cost effective. They are preferred in many industrial applications, such as metal finishing, cutting, and polishing. In the United States, large volumes of abrasives also are used in cutting and finishing wallboard and timber. The abrasives market is mature, and the use of various manufactured abrasive materials is fairly well defined by application (Kendall, 2001, p. 55).

Fused Aluminum Oxide

Production.—Production data for regular and high-purity fused aluminum oxide in this report were obtained by the U.S. Geological Survey (USGS) from producers in Canada and the United States. The data were collected from two companies that operated three plants and represented the entire Canadian and United States fused aluminum oxide industry (table 1). Saint-Gobain Abrasives operated a fused aluminum oxide plant in the United States, and Washington Mills Electro Minerals Corp. operated fused aluminum oxide plants in Canada and the United States. Quantity data from the two countries were combined to avoid disclosing company proprietary data and are reported by the producers, estimated, and rounded to the nearest 5,000 t.

Production of regular-grade fused aluminum oxide in 2009 was an amount rounded to 10,000 t with a value rounded to $1.7 million. The weight and value were unchanged compared with 2008 regular-grade fused aluminum oxide production (table 2). Reporting on the output of high-purity fused aluminum oxide has been discontinued to avoid disclosing company proprietary data.

Consumption.—Abrasive-grade fused aluminum oxide has many end uses. Specific applications in 2009 included antislip additives, bonded abrasives (such as abrasive grains that are made to adhere to each other and then are pressed or molded into abrasive tools), buffing/polishing compounds, coated abrasives (such as abrasive grains glued to a backing of paper or cloth), dry or wet blasting media, and tumbling media. Fused aluminum oxide in a micropowder form was used for industrial and electronic applications that require fine surface finishing. Fused aluminum oxide does not face any significant substitution threats at present as it is generally a very cost-effective abrasive. The total 2009 U.S. apparent consumption of all forms of fused aluminum oxide was estimated to be 35,900 t, with a value of $21.8 million, based on the average customs unit value for imports.

Prices.—The USGS canvassed fused aluminum oxide producers to determine the total value of their production for the year. The survey indicated that the average unit value of regular fused aluminum oxide produced in Canada during 2009 was $165 per metric ton at the point of production; the average value of high-purity fused aluminum oxide output was $671 per ton at the point of production. Prices of abrasive grain produced from these materials and sold to consumers were significantly higher.

Average unit values of fused aluminum oxide traded by the United States in 2009 as reported in this publication are based on U.S. Census Bureau data. The average value for U.S. exports of crude fused aluminum oxide during the year was about $2,600 per ton. The average customs value of crude fused aluminum oxide imports during the year was $608 per ton, but values ranged from $181 per ton (Hungary) to $7,870 per ton (Slovakia), and those of fused aluminum oxide grain imports averaged $1,170 per ton and ranged from $788 per ton (Brazil) to $1.22 million per ton (Israel). The extremely high values represent small quantities of highly specialized materials.

Foreign Trade.—Compared with those of the previous year, crude fused aluminum oxide exports in 2009 decreased by 44% to 12,300 t, and the value of those exports decreased by 46% to $32.0 million (table 5). Of the exports shipped to 34 countries, 81% went to Canada, Mexico, Germany, and Japan, in decreasing order by quantity.

During 2009, imports of crude fused aluminum oxide were received from 13 countries and decreased by 84% to 38,200 t valued at $23.2 million compared with those of 2008; imports of ground and refined fused aluminum oxide were received from 21 countries and decreased by 36% to 26,000 t valued at $30.5 million (table 6). Some of the imported crude fused aluminum oxide was refractory-grade material. China, Canada, and Venezuela supplied 63%, 22%, and 13%, respectively, of the crude imports. Compared with those of 2008, crude imports from Canada increased to 8,450 t from 2,720 t, while imports from China decreased from 215,000 t to 24,200 t, and those from Venezuela decreased from 15,900 t to 5,090 t. Brazil, Germany, Austria, China, Hungary, and Italy provided 36%, 19%, 16%, 14%, 4%, and 4%, respectively, of the ground and refined material.

Silicon Carbide

Production.—One company produced abrasive-grade silicon carbide in the United States during 2009 (table 1). This company also produced similar amounts of metallurgical-grade silicon carbide. A second company, in Hopkinsville, KY, produced a small quantity of silicon carbide, primarily intended for use in heat-resistant products rather than abrasives. U.S. silicon carbide production decreased slightly during 2009 to an estimated 35,000 t, and the value of production decreased slightly to $25.9 million (table 2).

Consumption.—Abrasive-grade silicon carbide has many end uses. Specific applications in 2009 included antislip abrasives, blasting abrasives, bonded abrasives, coated abrasives, polishing/buffing compounds, tumbling media, and wiresawing abrasives. The total abrasive-grade silicon carbide consumed in the United States in 2009 was about 77,900 t valued at about $33.1 million.

Prices.—Based on information from industry sources and publications, the average value of abrasive-grade silicon carbide at the point of manufacture was $739 per ton in 2009, which was unchanged compared with that of the previous year. The average value for U.S. crude silicon carbide exports in 2009 was $1,550 per ton, a 34% decrease compared with that of the previous year. The average value for U.S. ground silicon carbide exports was $3,070 per ton, a 10% decrease compared with that of the previous year.

Crude silicon carbide imports from China had an average value of $604 per ton. The average value of crude silicon carbide imports from other countries was $465 per ton. Silicon carbide grain imports from China material had an average customs value of $1,380 per ton. The average customs value of silicon carbide grain imports from other countries was $2,795 per ton (table 6).

Global prices for silicon carbide steadily increased throughout 2008 despite poor global economic conditions (Kennedy, 2008); however, the poor global economic conditions did cause average prices to drop each quarter during 2009. This trend was demonstrated by the quarterly average unit values for imports of both types of crude silicon carbide. Crude silicon carbide unit values decreased from $692 per ton in the first quarter to $442 per ton in the fourth quarter, and silicon carbide grain unit values decreased from $2,660 per ton in the first quarter to $1,880 per ton in the fourth quarter of 2009.

Foreign Trade.—In 2009, the United States exported crude silicon carbide to 22 countries and refined and ground silicon carbide to 36 countries. The total crude silicon carbide exports for 2009 increased by 60% compared with those of the previous year to 16,900 t valued at $26.2 million (table 5). Of the exported crude silicon carbide material, 79% was shipped to Norway. Compared with those of 2008, exports of refined or ground silicon carbide decreased by 42% to 3,750 t valued at $11.5 million. Of the exported refined and ground material, 45% was shipped to Canada.

In 2009, the United States imported crude silicon carbide from 15 countries and imported ground and refined silicon carbide from 23 countries. Imports of crude silicon carbide decreased by 31% during the year to 59,900 t valued at $33.4 million (table 6). Imports of silicon carbide in ground or refined form decreased by 54% to 18,100 t valued at $41.1 million. China accounted for 66% of the crude silicon carbide imports and 37% of the ground and refined silicon carbide imports. A large part of the imports from China reportedly included metallurgical-grade material.

Aluminum-Zirconium Oxide

During 2009, fused aluminum-zirconium oxide for abrasive applications, such as resin-bonded grinding wheels, was produced at one plant in the United States, belonging to Saint-Gobain Abrasives, and one plant in Canada, belonging to Saint-Gobain Ceramic Materials Canada Inc., but production data from these plants are withheld to avoid disclosing company proprietary information.

Boron Carbide

Washington Mills Electro Minerals was the only commercial producer of boron carbide in the United States during 2009. Boron carbide was used as an abrasive for lapping and ultrasonic cutting operations previously possible only with diamond dust; it was also molded to form highly wear-resistant products, such as pressure blasting nozzles, wire-drawing dies, powdered metal and ceramic forming dies, thread guides, and armor. Boron carbide also was used in nuclear applications, such as reactor control rods and neutron-absorbing shielding (Washington Mills Electro Minerals Corp., 2008). Domestic production data for boron carbide are withheld to avoid disclosing company proprietary data.

Metallic Abrasives

Production.—Data on U.S. production and shipments of metallic abrasives were based on a survey of domestic producers conducted by the USGS. Survey data were collected from 11 companies operating 12 plants in the United States and accounted for all domestic production (table 3).

Steel shot and grit accounted for almost all the metallic abrasives produced domestically (table 4). U.S. production of steel shot and grit in 2009 decreased by 35% compared with that of 2008; the average unit value in 2009 was $474 per ton. Six companies reported production of cut wire shot in 2009, and most of that was cut from carbon steel wire and stainless steel wire. Other products reported included shot cut from aluminum, copper, and zinc wire. One company reported production of steel nuggets, a wrought carbon steel blast medium with properties similar to steel shot.

Consumption.—Metal abrasives are used primarily as loose particles propelled at high velocities for blast cleaning or to improve the properties of metal surfaces; 75% of the abrasives is employed in cleaning operations. Principal consumers include foundries, machine tool industries, metalworking plants (particularly those supporting the automotive and aircraft industries), and steel manufacturers.

During 2009, total sales of all steel shot and grit by U.S. producers decreased by 25% compared with shipments in 2008 to 151,000 t with an average value of $555 per ton sold or used.

Prices.—The USGS compiles survey data on the value of production and shipments, but it does not collect price data. The values of production and shipments reported by metallic abrasive producers in 2009 are listed in table 4. Average unit values of steel shot and grit ranged from $0.33 to $1.06 per kilogram. Average unit values of cut wire shot ranged from $1.90 to $5.75 per kilogram for carbon steel, stainless steel, and zinc wire shot. Average unit values for metallic abrasives traded by the United States during 2009 were $1.24 per kilogram for exports and $0.76 per kilogram for imports.

Foreign Trade.—During 2009, the United States exported metallic abrasives to 45 countries and imported metallic abrasives from 17 countries. U.S. exports of metallic abrasives decreased by 25% during the year to 25,900 t valued at $32.2 million (table 5). Canada, China, and Mexico received 82% of the U.S. exports of metallic abrasives in 2009. U.S. imports decreased by 57% during 2009 to 15,800 t valued at $12.1 million (table 6). About 81% of the imports came from Canada, China, Germany, and Sweden.

Outlook

Abrasives markets are greatly influenced by activity in the manufacturing sector in the United States. During the past year, downturns in the U.S. manufacturing sector owing to the impacts of the global economic recession have caused decreases in U.S. manufactured abrasives production and consumption. This is particularly true of manufacturing activities in the aerospace, automotive, furniture, housing, and steel industries. Even though abrasives markets are linked to these end-use manufacturing sectors, growth in these sectors may not necessarily lead to an increase in abrasives consumption. The U.S. abrasive markets also are influenced by economic and technological trends. As the world and the United States slowly begin to recover from the global economic recession, it is most likely that U.S. manufactured abrasives production and consumption will also slowly begin to show signs of improvement.

Improved technology in these manufacturing sectors has resulted in surface quality that requires fewer grinding and finishing operations that use abrasives (O'Driscoll, 2003). Less expensive imports coupled with higher domestic production costs and low domestic production capacity continue to challenge U.S. producers of fused aluminum oxide and silicon carbide to maintain market share. Competition from developing nations, especially China, will probably lead to further decreases in domestic output. China has become a dominant force in both fused aluminum oxide and silicon carbide production in recent years. This has changed the makeup of the manufactured abrasives market. Lower priced Chinese exports have displaced and are expected to continue to displace manufactured abrasives produced in Europe and North America (Gasser, 2002). The traditional suppliers among the Western industrialized nations are expected to continue consolidating and contracting.

Emerging suppliers of fused aluminum oxide and silicon carbide in China, Eastern Europe, India, the Republic of Korea, and South America are likely to continue to increase their prominence in world markets. Further success for these suppliers, particularly in such major markets as Japan, the United States, and Western Europe, will depend on their ability to provide higher grades of material and levels of supply reliability while maintaining lower prices. Energy costs, furnace size, quality-control systems, and the availability of essential mineral inputs are expected to be the dominant factors influencing the competitive stance of these suppliers.

The aerospace and automotive manufacturing sectors are likely to continue to be significant indirect influences on demand for manufactured abrasives used by metalworking operations supporting those sectors. The housing construction sector in North America is expected to continue to have an indirect influence on demand for manufactured abrasives because of the large volumes of manufactured abrasives used in cutting and finishing wallboard and timber.

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Other

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Industrial Minerals, monthly.

TABLE 1

CRUDE ARTIFICIAL ABRASIVES MANUFACTURERS IN 2009

Company	Plant location	Product
Saint-Gobain Ceramic Materials Canada Inc.	Chippewa, Ontario, Canada	Aluminum-zirconium oxide.
Saint-Gobain Abrasives	Huntsville, AL	Fused aluminum oxide (high-purity) and aluminum-zirconium oxide.
Washington Mills Electro Minerals Corp.	Niagara Falls, NY	Fused aluminum oxide (high-purity) and boron carbide.
Do.	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular).
Washington Mills Hennepin, Inc.	Hennepin, IL	Silicon carbide.

Do. Ditto.

TABLE 2

ESTIMATED PRODUCTION OF CRUDE SILICON CARBIDE AND FUSED ALUMINUM OXIDE IN THE UNITED STATES AND CANADA[1, 2]

	2008		2009	
Product	Quantity[3, 4] (metric tons)	Value[3] (thousands)	Quantity[3, 4] (metric tons)	Value[3] (thousands)
Aluminum oxide, regular, abrasives[5]	10,000	$1,700	10,000	$1,700
Silicon carbide[6]	35,000	25,900	35,000	25,900

[1] Data are rounded to no more than three significant digits.

[2] Yearend stock data are withheld to avoid disclosing company proprietary data.

[3] Owing to rounding, data do not match total quarterly Mineral Industry Surveys estimated data.

[4] Quantities are rounded to the nearest 5,000 metric tons to avoid disclosing company proprietary data.

[5] Regular grade accounts for about 62% of total output, and high-purity material accounts for the remainder.

[6] Approximately one-half of the quantity and value consists of material for metallurgical and other nonabrasive applications.

TABLE 3
U.S. PRODUCERS OF METALLIC ABRASIVES IN 2009

Company	Plant location	Product [shot and (or) grit]
Abrasive Materials, LLC	Hillsdale, MI	Cut wire.
Chesapeake Specialty Products, Inc.	Baltimore, MD	Steel.
Ervin Industries, Inc.	Adrian, MI	Do.
Do.	Butler, PA	Do.
Frohn North America, Inc.	Austell, GA	Cut wire.
MLP Steel, LLC (formerly Marwas Steel Co.)	Scottdale, PA	Do.
Metaltec Steel Abrasive Co.	Canton, MI	Steel.
Peerless Metal Powders & Abrasive Co., Inc.	Detroit, MI	Steel and steel nuggets.
Pellets, LLC	Tonawanda, NY	Cut wire.
Platt Brothers & Co., Inc., The	Waterbury, CT	Do.
Premier Shot Co.	Cleveland, OH	Do.
Wheelabrator Abrasives Inc.	Bedford, VA	Steel.

Do. Ditto.

TABLE 4
PRODUCTION AND SHIPMENTS FOR METALLIC ABRASIVES IN THE UNITED STATES, BY PRODUCT[1]

Product	Production		Shipments[2]	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2008:				
Steel shot and grit	210,000	$98,100	201,000	$94,300
Cut wire shot and other[e]	1,910	7,710	1,910	8,460
Total	212,000	106,000	203,000	103,000
2009:				
Steel shot and grit	137,000	64,900	151,000	83,700
Cut wire shot and other[e]	1,470	5,390	1,490	5,800
Total	138,000	70,300	152,000	89,500

[e] Estimated.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes reported exports.

TABLE 5

U.S. EXPORTS OF ALUMINUM OXIDE, SILICON CARBIDE, AND METALLIC ABRASIVES, BY COUNTRY AND TYPE[1]

	2008		2009	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Aluminum oxide, crude:				
Brazil	682	$2,710	141	$650
Canada	8,160	8,740	5,470	7,210
China	248	1,700	143	959
Germany	3,760	15,400	1,680	6,020
India	308	1,280	189	878
Japan	2,010	8,640	724	4,450
Korea, Republic of	910	5,680	430	3,180
Mexico	3,000	4,890	2,060	3,430
United Kingdom	1,370	2,750	634	1,640
Other	1,450 [r]	7,210 [r]	854	3,620
Total	21,900	59,000	12,300	32,000
Silicon carbide:				
Crude:				
Germany	8	1,080	2,550	3,020
Japan	142	2,130	32	458
Mexico	626	1,760	759	1,310
Norway	9,650	16,700	13,400	19,500
Other	151 [r]	3,030 [r]	182	1,890
Total	10,600	24,700	16,900	26,200
Ground and refined:				
Canada	3,260	3,910	1,680	2,540
China	249	531	71	475
Germany	360	10,700	349	4,440
Japan	568	2,320	270	873
Mexico	1,140	1,350	996	1,570
Norway	97	206	76	158
United Kingdom	232	387	25	26
Other	509 [r]	2,480 [r]	280	1,410
Total	6,420	21,900	3,750	11,500
Metallic abrasives:				
Canada	9,820	8,890	5,160	4,730
China	11,400	17,800	7,470	10,400
Germany	201	448	172	572
Indonesia	167	124	824	1,500
Japan	788	1,090	963	972
Mexico	8,800	11,300	8,750	9,390
Taiwan	633	661	458	447
United Kingdom	1,350	3,810	753	2,080
Other	1,170 [r]	4,330 [r]	1,370	2,170
Total	34,400	48,500	25,900	32,200

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS OF ALUMINUM OXIDE, SILICON CARBIDE, AND METALLIC ABRASIVES, BY COUNTRY AND TYPE[1]

Country	2008		2009	
	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Aluminum oxide:				
Crude:				
Canada	2,720	$1,840	8,450	$6,530
China	215,000	107,000	24,200	12,900
Venezuela	15,900	10,400	5,090	3,610
Other	10,600	5,720	489	181
Total	244,000	125,000	38,200	23,200
Ground and refined:				
Austria	7,390	11,000	4,210	7,100
Brazil	12,800	12,100	9,240	7,280
Canada	819	1,280	390	804
China	1,680	1,480	3,710	2,920
France	1,500	3,040	402	873
Germany	11,500	15,200	5,020	7,390
Hungary	1,240	1,150	1,100	1,090
Italy	2,240	2,120	982	1,210
Other	1,600 r	2,810 r	963	1,820
Total	40,800	50,300	26,000	30,500
Silicon carbide:				
Crude:				
China	82,300	67,500	39,700	24,000
Netherlands	--	--	4,540	1,330
Venezuela	2,600	1,230	4,500	2,000
Other	2,470 r	4,240 r	11,200	6,070
Total	87,300	72,900	59,900	33,400
Ground and refined:				
Brazil	8,550	12,000	4,000	5,760
China	18,400	25,400	6,660	9,200
Germany	1,340	5,740	1,570	6,800
Japan	1,680	10,700	1,070	7,330
Norway	2,640	14,500	1,660	8,120
Russia	614	646	1,280	1,410
Vietnam	2,960	2,160	1,120	1,080
Other	3,410 r	4,630 r	725	1,430
Total	39,600	75,700	18,100	41,100
Metallic abrasives:				
Canada	11,900	8,690	6,380	3,920
China	2,030	3,120	1,690	3,680
Germany	2,120	2,760	1,300	1,040
Sweden	16,600	9,470	3,400	1,100
Other	3,980	4,260	3,040	2,330
Total	36,600	28,300	15,800	12,100

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

Source: U.S. Census Bureau.

ALUMINUM

By E. Lee Bray

Domestic survey data and tables were prepared by Paula R. Neeley, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

During 2009, primary aluminum production fell to the lowest level since 1961 owing to declining demand and falling prices in the wake of the continuing effects of the global financial crisis of 2008. Domestic primary smelters produced 1.73 million metric tons (Mt) of aluminum metal, 35% less than that in 2008 (table 1). The value of production fell to $3.03 billion, 57% less than the value of production in 2008. At yearend, five companies were operating nine domestic primary aluminum smelters in seven States. Smelters east of the Mississippi River accounted for about 77% of production. During the year, in response to lower aluminum prices and weaker demand, four smelters were idled, in addition to four that had been closed temporarily prior to 2009. Demolition of another smelter that had been closed since 2002 was completed during the year. At yearend 2009, about 52% [1.83 million metric tons per year (Mt/yr)] of domestic primary aluminum smelting capacity, including idle potlines at operating smelters, was not being utilized.

In 2009, aluminum recovered from purchased scrap decreased to 2.71 Mt. Of this recovered metal, 56% came from new (manufacturing) scrap, and 44% came from old (obsolete aluminum products) scrap. Aluminum used beverage cans (UBCs) accounted for 22% of the reported old scrap consumed.

Apparent consumption fell by 13% compared with that in 2008 (table 1). The container and packaging industry surpassed the transportation industry as the leading market for aluminum products in Canada and the United States. The container and packaging industry accounted for 26.5% of United States and Canadian metal shipments; transportation, 23.7%; building and construction, 11.9%; electrical, 7.3%; machinery and equipment, 5.9%; consumer durables, 5.7%; and other uses, 3.1%. Exports accounted for 15.9% of shipments from producers in Canada and the United States in 2009 (table 6).

The 2009 average U.S. market price of primary aluminum ingot decreased by 34% to $0.794 per pound from $1.205 per pound in 2008 (table 8). With the onset of the global economic crisis in the fourth quarter of 2008, the average monthly price fell from $1.29 per pound in August 2008 to $0.71 per pound at yearend 2008. The price reached a low of $0.629 in February 2009 and remained below $0.75 per pound through June when it began to trend upward, reaching an average of $1.04 per pound in December.

At yearend 2009, total world inventories of aluminum of 7.12 Mt, as reported by the International Aluminium Institute (IAI) and the London Metal Exchange Ltd. (LME), were 26% higher than those at yearend 2008. Total aluminum inventories of 2.23 Mt reported by the IAI were 25% lower than those at yearend 2008. Combined inventories of aluminum metal and alloys held by the LME increased by 82% to reach 4.89 Mt (London Metal Exchange Ltd., 2008, 2009; International Aluminium Institute, 2010).

Primary aluminum was produced in 43 countries in 2009. China, Russia, Canada, and Australia, in decreasing order of metal produced, accounted for 58% of total world production. World primary metal production decreased by 6% compared with that of 2008 primarily owing to declines in production in the United States [931,000 metric tons (t)], Russia (375,000 t), Germany (314,000 t), China (300,000 t), Norway (228,000 t), Brazil (125,000 t), Canada (90,000 t), the United Kingdom (73,000 t), and Ukraine (63,000 t). These declines were partially offset by increased production in Oman (302,000 t), India (93,000 t), and the United Arab Emirates (62,000 t) as new smelters and expansions were commissioned in these countries. The United States ranked fifth (down from fourth) leading producer of primary aluminum.

Production

Primary.—Owing to declining demand and falling prices, several smelters were closed or reduced production. In efforts to remain competitive at relatively low prices, a number of new power contracts were negotiated.

Alcoa Inc. (Pittsburgh, PA) closed its 215,000-metric-ton-per-year (t/yr) smelter at Alcoa, TN, citing declining prices and lower demand. One potline was shut down in January, with the remainder of production ceasing by the end of March (Alcoa Inc., 2009e).

In January, Alcoa signed an amended power sales agreement with the Bonneville Power Administration (BPA) for power to its 278,000-t/yr Intalco smelter at Ferndale, WA, replacing the contract that had been nullified by the U.S. Court of Appeals for the Ninth Circuit in 2008 (Bonneville Power Administration Journal, 2009). In December, Alcoa and the BPA signed a new power supply contract that would increase the power provided to the smelter to an average 320 megawatts (MW) by March 2010 from an average 285 MW. The contract was divided into two phases, the first extending through May 2011, and the second phase lasting an additional 5 years. The second phase would be contingent on several factors, including resolution of earlier concerns of the court. Alcoa agreed to maintain an average of 528 full-time employees at the smelter through 2016 (Alcoa Inc., 2009b; Bonneville Power Administration Journal, 2010).

In January, Alcoa signed a power supply contract with the New York Power Authority (NYPA) to supply Alcoa's two smelters at Massena, NY. The 30-year contract would start with the expiration of the current contract in 2013 and included a 10-year extension option. The terms of the contract required a modernization project to reduce emissions and increase total capacity to 278,000 t/yr from 255,000 t/yr at the two smelters. In May, Alcoa closed the 125,000-t/yr Massena East smelter. The low price of aluminum was cited as the reason for the closure. In an agreement with NYPA, Alcoa retained 250 of the 420 affected employees to prepare the shuttered plant for the modernization project (Alcoa Inc., 2009d, i).

In March, Century Aluminum Co. (Monterey, CA) closed one potline at the 244,000-t/yr smelter at Hawesville, KY, reducing production by approximately 50,000 t/yr. Low aluminum prices were cited as the reason for the closure (Century Aluminum Co., 2009b). In May, Century closed an additional 31 pots at the smelter, but at the end of July, restarted 21 pots as aluminum prices increased (Platts Metals Week, 2009b, c). Also in July, Century announced that a new power supply contract for the Hawesville smelter had been signed with Big Rivers Electric Corp. (Henderson, KY) and E.On USA (Louisville, KY). The contract replaced the previous contract and would last through 2023, supplying enough power to operate the smelter at full capacity (Century Aluminum Co., 2009a).

Century closed its 270,000-t/yr smelter in Ravenswood, WV, at the end of February. The company had previously shut down one potline at the smelter in December 2008 in response to declining prices for aluminum (Century Aluminum Co., 2009c).

In February, Columbia Falls Aluminum Co. (CFAC) (Columbia Falls, MT) and the BPA negotiated an amended power contract, the original contract having been overturned by the court. The new contract included provisions for CFAC to continue production from one-half of one potline at its 168,000-t/yr smelter at Columbia Falls through June. The company had previously announced that all production would be shut down by the end of February because of the court ruling and declining aluminum prices (Bonneville Power Administration Journal, 2009). In July, CFAC announced that it would continue to operate one-half of one potline through September. A second short-term power supply contract was obtained with the BPA that enabled the smelter to operate while the parties continued to negotiate a long-term power supply contract (Platts Metals Week, 2009d). A long-term power contract was not achieved, however, given the constraints of the court order that prohibited a contract from benefiting CFAC at the expense of higher rates for other consumers, and all production was shut down at the end of October (Jamison, 2009).

On January 28, a power outage at Noranda Aluminum Holding Corp. (Franklin, TN) caused by severe weather forced the shutdown of approximately 75% of the capacity of its 250,000-t/yr smelter at New Madrid, MO. At the beginning of May, the smelter was operating at more than 50% of capacity, and the restart of the final potline was initiated in October, with production at full capacity expected early in 2010 (Noranda Aluminum Holding Corp., 2009a, b, c, p. 1).

In May, Ormet Corp. cut back production at its 265,000-t/yr smelter at Hannibal, OH, and by early August had closed two of six potlines. A shortage of alumina provided by Glencore International AG (Baar, Switzerland) was cited as the reason for the shutdown. Glencore had informed Ormet that alumina deliveries to the Hannibal smelter from the temporarily closed Windalco refinery in Jamaica would stop in April. Glencore stated that the tolling agreement with Ormet allowed it to cease deliveries without supplying alumina from an alternative source. The tolling agreement was terminated as a result of an arbitration ruling, freeing Ormet to obtain alumina from another supplier to enable operation of four potlines at least through yearend 2010. Ormet also secured a power contract with American Electric Power Co. Inc. (Columbus, OH), effective September 2009 through yearend 2018, and extended through May 31, 2011, the labor contract with the United Steelworkers of America, which had been set to expire at yearend (Ormet Corp., 2009a, p. 2; b).

In July, Rio Tinto Alcan Inc. announced that a new power supply contract had been signed with Big Rivers Electric and E.On. The contract replaced the previous contract and would last through 2023, supplying enough power to operate the 196,000-t/yr Sebree, KY, smelter at full capacity (Rio Tinto Alcan Inc., 2009a). A project to replace the anode furnace at the Sebree smelter was being considered, and a decision was expected in 2010. The existing anode furnace was 35 years old and replacing it would reportedly enhance the smelter's future competitiveness. The United Steelworkers union and Rio Tinto agreed to a 5-year contract through yearend 2014, which had been a stated prerequisite of Rio Tinto to consider any capital investment at the smelter (Platts Metals Week, 2009a, g).

Demolition of buildings at Vancouver Aluminum Co.'s smelter in Vancouver, WA, which started in 2008, was completed in February. The 116,000-t/yr smelter was built in 1940 and was last operated in 2002 when it was shut down as a result of high power prices. The smelter was last owned by Evergreen Aluminum (a subsidiary of Glencore) but Alcoa had retained ownership of several fabrication buildings and the adjacent land and reportedly agreed to be responsible for environmental damages that occurred prior to the sale of the smelter in 1987. Remediation was underway, and when completed, the site would be sold to the Port of Vancouver for other industrial use (Washington State Department of Ecology, 2007; Alcoa Inc., 2008).

Secondary.—In the fourth quarter of 2009, Imperial Aluminum LLC reopened secondary smelters in Minerva, OH, and Scottsboro, AL. Imperial acquired the smelters following the December 2008 bankruptcy of their previous owner, Commercial Alloys Inc. Each smelter was reported to have a capacity of 40,800 t/yr (Schaffer, 2009).

Spectro Alloys closed an undisclosed amount of secondary smelting capacity in March as a result of declining demand from the automotive industry. The smelter, which produced alloys commonly used in the automotive industry, had a capacity of 110,000 t/yr. Numerous other secondary smelters reportedly were cutting production in the wake of the bankruptcy proceedings of General Motors Corp. and Chrysler LLC, as the automakers and their suppliers shut production for an extended period of time during the first half of 2009 (Petersen, 2009b; Petersen and others, 2009).

Consumption

Apparent consumption of aluminum in the United States declined by 13% in 2009 compared with that in 2008. Shipments of aluminum by United States and Canadian producers to their combined domestic markets declined by 21% in 2009 compared with the amount shipped in 2008. Shipments of aluminum for containers and packaging, the leading end use, declined by 4% compared with those in 2008. Shipments decreased in the transportation sector by 32%, consumer durables by 25%, building and construction by 18%, electrical by 15%, and the machinery sector by 31%.

The decline in shipments of aluminum to the transportation sector resulted primarily from a reduction in automobile production. Production of light vehicles in North America declined by 32% in 2009 compared with production in 2008. Light vehicle production in all months of 2009 except November and December declined compared with production in the same month of 2008. Production in the first half of 2009 declined by more than 50% compared with production in the first half of 2008, while factories were shut down for an extended time during the bankruptcies of General Motors and Chrysler (CSM Worldwide Inc., 2009, 2010).

Increased aircraft production partially offset the decline in shipments of aluminum for use in transportation to automakers. The Boeing Co. (Chicago, IL) reported that deliveries of commercial aircraft were 28% higher than those in 2008. The reestablishment of normal operations after a 2-month strike during 2008 and continued modernization of fleets by commercial airlines to replace older aircraft with more fuel efficient models were reasons cited for the increased aircraft production (Boeing Co., The, 2010, p. 3–4).

The decline in aluminum shipments for use in building and construction was mainly a result of reduced home construction. The U.S. Census Bureau and the U.S. Department of Housing and Urban Development jointly reported that housing starts were down by 39% in 2009 compared with starts in 2008. The number of houses completed during 2009 was 29% fewer than the number completed in 2008 (U.S. Census Bureau, 2010b). Spending on nonresidential construction during 2009 decreased by 12% compared with this type of spending in the prior year (U.S. Census Bureau, 2010a).

A study commissioned by The Aluminum Association Inc. showed that the aluminum content of light vehicles manufactured in 2009 averaged 112 kilograms (kg) [248 pounds], and accounted for 8.6% of the vehicle weight, compared with 5.1% in vehicles manufactured in 1990. The study projected that the aluminum content in automobiles will average 136 kg (300 pounds) by 2020. The growth in the use of aluminum in automobiles was attributed to substitution for steel in engine blocks, hoods, steering knuckles, and wheels. Reduction in vehicle weight to meet new fuel efficiency regulations in the United States and other nations was cited as the reason for growth in aluminum usage (Light Metal Age, 2009, p. 44).

Stocks

The Aluminum Association reported the combined inventories of aluminum ingot, mill products, and scrap of United States and Canadian producers declined by 23% to 937,000 t at yearend 2009 from 1.22 Mt at yearend 2008 (Aluminum Association Inc., The, 2010). The LME reported that primary aluminum metal ingot stocks at LME U.S. warehouses increased by 94% to 2.02 Mt at yearend 2009 from 1.05 Mt at yearend 2008. At yearend 2009, LME warehouses in the United States also held about 180,000 t of North American special aluminum alloy contract (NASAAC) metal ingot, a 27% decrease from the 245,000 t held at yearend 2008 (London Metal Exchange Ltd., 2008, 2009).

Prices

The monthly average U.S. market price of primary aluminum metal, as reported by Platts Metals Week, started the year at $0.676 per pound in January and stayed below $0.750 per pound until July, when the price began a general upward trend for the remainder of the year as the impacts of the financial crisis started to ebb, reaching $1.038 per pound in December. The annual average price in 2009 decreased to $0.794 per pound from $1.205 per pound in 2008 as demand increased from the lowest levels during the financial crisis but did not recover to precrisis levels. The LME monthly average cash prices for primary aluminum ingot followed the same general trend as the U.S. market price. The 2009 annual average LME cash price for high grade primary aluminum ingot decreased to $0.755 per pound from $1.167 per pound in 2008. The indicator prices for selected secondary aluminum ingots and aluminum scrap, as published in American Metal Market, followed the same trend as primary ingot prices (table 8).

Foreign Trade

Exports of crude aluminum decreased by 15% and exports of semifabricated aluminum materials decreased by 21%, compared with those of 2008 (table 9). Net exports of 1.22 Mt of scrap decreased by 18% compared with the amount in 2008. About 74% of total U.S. exports (crude, semifabricated, and scrap) in 2009 were shipped to China, Canada, and Mexico. Scrap accounted for 61% of total exports, 59% of which went to China (table 10).

In 2009, total net imports of unmanufactured aluminum-base materials increased by 53% compared with net imports in 2008. Imports for consumption of crude aluminum increased by 4%, while imports of semifabricated aluminum materials (plates, sheet, pipes, bars, etc.) decreased by 14% compared with those of 2008 (table 11). Canada remained the leading source country, accounting for 63% of the total imports in 2009, and Russia continued to be the second ranked supplier, accounting for 9% of total imports of aluminum (table 12).

World Industry Structure

Production.—World primary aluminum production decreased by 4% in 2009 compared with that of 2008, corresponding to smelter closures in the wake of the financial crisis (table 13). China, Russia, Canada, and Brazil, in decreasing order of production, accounted for 58% of total world primary aluminum production.

Stocks.—Owing to the continued collapse of demand that began in the second half of 2008, yearend global inventories of crude aluminum increased by 40% from the yearend 2008 level. Unwrought aluminum inventories held by member producers of the IAI decreased by 28% to 1.20 Mt at yearend 2009 from 1.68 Mt at yearend 2008. Unwrought aluminum is defined by the IAI as aluminum in its basic form made from primary metal or from scrap and that is unworked in the metallurgical sense. Total IAI aluminum inventories [unwrought aluminum plus unprocessed scrap, metal in process, and finished semifabricated (mill) products] decreased by 25% to 2.23 Mt at yearend 2009 from 2.96 Mt at yearend 2008 (International Aluminium Institute, 2010).

Yearend 2009 inventories of primary aluminum metal held by the LME increased by 98% to 4.62 Mt from 2.34 Mt at yearend 2008; aluminum alloy inventories decreased by 18% to 84,500 t from 104,000 t; and NASAAC ingot inventories decreased by 27% to 180,000 t from 245,000 t (London Metal Exchange Ltd., 2008, 2009).

Mergers and Acquisitions.—Alcoa completed its acquisition of the Lista and Mosjoen primary smelters in Norway from Orkla ASA in March. The smelters had capacities of 94,000 t/yr and 188,000 t/yr, respectively. The deal also included an anode plant adjacent to the Mosjoen smelter. In exchange, Orkla received Alcoa's 45% share of Sapa Extrusions Inc. to reach 100% ownership (Alcoa Inc., 2009c).

At the end of July, Alcoa completed the sale of its interest in Rio Tinto plc to Aluminum Corp. of China (Chinalco). In February 2008, Alcoa and Chinalco had jointly acquired 12% of the stock in Rio Tinto. A change in strategy in light of the economic conditions was cited as the reason for the sale (Alcoa Inc., 2009h).

Rio Tinto sold its half of the Ningxia smelter in China to its joint-venture partner, Qingtongxia Aluminium Group Co. Ltd. in January. The smelter had a capacity of 160,000 t/yr (Rio Tinto plc, 2009a).

In February, Klesch & Co. Ltd. (London, United Kingdom) completed the acquisition of smelters at Delfzijil, Netherlands, and Voerde, Germany, from Corus Group plc (London). Each smelter had a capacity of 100,000 t/yr (Klesch and Co. Ltd., 2009).

As part of a financial restructuring deal, the Government of Montenegro received ownership of 29.4% of Kombinat Aluminijuma Podgorica and Bauxite Mines (KAP). Central European Aluminum Co. remained the managing partner of the joint venture with 29.4% ownership, with the remainder owned by other investors. Assets owned by KAP included a 120,000-t/yr smelter and a 280,000-t/yr alumina refinery at Podgorica and a 700,000-t/yr bauxite mine at Kutsko Brdo (Central European Aluminum Co., 2009, 2010).

Citing declining demand, lower prices, and lack of credit, Aleris International Inc. filed for chapter 11 bankruptcy protection in February. The secondary aluminum producer was able to continue operations through a debtor-in-possession facility. The company continued operating under bankruptcy protection throughout the year (Aleris International Inc., 2009).

Sapa Group acquired the assets of Indalex during the liquidation of Indalex. Indalex had filed for bankruptcy citing credit issues and a decline in business to automotive and construction markets. The Indalex assets in the United States included six extrusion plants and a secondary casthouse. Indalex also had five extrusion plants and a casthouse in Canada (Petersen, 2009a; Sapa Group, 2009).

World Review

Australia.—The Government of Australia was moving forward with a proposed cap-and-trade plan in an effort to reduce emissions of carbon dioxide and other greenhouse gases. The proposal included provisions for the aluminum industry and other emission-intensive industries to mitigate the cost increases during the first several years (Australian Department of Climate Change, 2009).

Alcoa and its joint-venture partners CITIC Ltd. (22.5%) and Marubeni Aluminium Australia Ltd. (22.5%) closed 53,000 t/yr of capacity at the Portland Aluminium smelter in response to declining prices and demand for aluminum. The first 15,000 t/yr of capacity was closed in December 2008, and an additional 38,000 t/yr was shut down by July 2009. The Portland smelter had a capacity of 358,000 t/yr (Alcoa Inc., 2009j).

Bosnia and Herzegovina.—Aluminij d.d. Mostar shut down approximately 35,000 t/yr of capacity at its 135,000-t/yr smelter during the early part of 2009 as a result of the global financial crisis and subsequent decline in prices. The company subsequently announced that production would be returned to full capacity during the fourth quarter (CRU Aluminium Monitor, 2009h).

Brazil.—In April, Vale SA closed all primary smelting capacity at the Valesul smelter in Santa Cruz. The 95,000-t/yr smelter had been operating at only 40% capacity since October 2008, using only power from its onsite powerplant. Starting in April 2009, the casthouse was used to make extrusion billets from scrap and primary ingot purchased from other smelters (Vale SA, 2009).

Brazil recycled 91.5% of all aluminum beverage cans sold during 2008. Brazil collected and recycled 165,800 t of UBCs, the equivalent of 12.3 billion aluminum cans. Although the recycling rate declined from 96.5% in 2007, for the eighth consecutive year, Brazil had the highest aluminum can recycling rate among countries that do not have mandatory recycling laws (Associação Brasileira do Alumínio, 2009).

Cameroon.—Production at the 100,000-t/yr Alucam smelter was cut by 20% compared with production in 2008 in response to declining prices and energy supply issues. The smelter was a joint venture between the Government of Cameroon and Rio Tinto (Rio Tinto plc, 2009b, 2010a, p. 15).

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China—China's Government purchased 290,000 t of aluminum in January from producers in an effort to remove surplus supplies from the market and prop up prices. The purchases were made from Chinalco and seven other companies owned in part by provincial governments. The stockpiling plan, which had been announced in December 2008, was part of a broader effort by the Strategic Reserve Bureau (SRB) to purchase metals from producers during the plunge of commodity prices during the global financial crisis. Despite the effort to stockpile surplus metal, many primary smelters cut production during the early part of the year (China Metal Market—Alumina and Aluminum, 2009k). In March, in addition to the SRB stockpile, the government of Henan Province announced plans to purchase 500,000 t of primary aluminum from provincial smelters. Henan Province accounts for approximately one-quarter of China's aluminum production (China Metal Market—Alumina and Aluminum, 2009g). The government of the Guangxi Zhuang Autonomous Region purchased 50,000 t of aluminum in March for a stockpile in an effort to provide support to smelters in the region (China Metal Market—Alumina and Aluminum, 2009d).

As prices on the Shanghai exchange increased in April, many smelters in China restarted capacity that had been idled during the fourth quarter of 2008. Smelters in Henan Province were reported to have restarted 800,000 t/yr of capacity as a result of higher aluminum prices and preferential power rates from the state-owned power company contingent upon increased employment and production. More than 200,000 t/yr of capacity was also restarted in Shanxi Province as the price for aluminum rebounded during April and May. Numerous smelters in other provinces were also reported to be restarting capacity during the same time (China Metal Market—Alumina and Aluminum, 2009i).

In April, the Henan Wanji Aluminum Smelter Co. restarted 65,000 t/yr of the 480,000 t/yr of capacity at the smelter in Wanji, Henan Province. The smelter had shut down production at the end of 2008 as prices collapsed (CRU Aluminium Monitor, 2009c). Also in April, Meishan Qimingxing Aluminum Co. restarted 80,000 t/yr capacity at its 125,000-t/yr smelter in Meishan Qimingxing, Sichuan Province as prices for aluminum increased. By August, all potlines had been restarted at the smelter. The smelter had shut down one-quarter of its capacity in December 2008 as prices declined during the global financial crisis (CRU Aluminium Monitor, 2009c, h). In May, Henkang Aluminium Co. restarted 240,000 t/yr of capacity at its 600,000-t/yr Yugang Longquan smelter in Henan Province. The potline had been completed and commissioned in 2008 but was shut down in December 2008 as a result of declining prices (CRU Aluminium Monitor, 2009d). Guizhou Shuangpai Aluminum Co., which was shut in October 2008, restarted production of aluminum from the 100,000-t/yr Lupanshui smelter in July as prices for aluminum increased. The restart was also enabled by a preferential power rate to the smelter (CRU Aluminium Monitor, 2009f).

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China's Government announced that new capacity expansions of aluminum smelters would not be permitted for 3 years. The Government also stated that 800,000 t/yr of outdated capacity would be eliminated by yearend 2010. The action was part of a policy aimed at reducing excess capacity and eliminating inefficient operations in energy-intensive industries. Strict control over the export of aluminum and other energy- and resource-intensive products was also part of the policy announced (China Metal Market—Alumina and Aluminum, 2009c).

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aluminum inventories [unwrought aluminum plus unprocessed scrap, metal in process, and finished semifabricated (mill) products] decreased by 25% to 2.23 Mt at yearend 2009 from 2.96 Mt at yearend 2008 (International Aluminium Institute, 2010).

Yearend 2009 inventories of primary aluminum metal held by the LME increased by 98% to 4.62 Mt from 2.34 Mt at yearend 2008; aluminum alloy inventories decreased by 18% to 84,500 t from 104,000 t; and NASAAC ingot inventories decreased by 27% to 180,000 t from 245,000 t (London Metal Exchange Ltd., 2008, 2009).

Mergers and Acquisitions.—Alcoa completed its acquisition of the Lista and Mosjoen primary smelters in Norway from Orkla ASA in March. The smelters had capacities of 94,000 t/yr and 188,000 t/yr, respectively. The deal also included an anode plant adjacent to the Mosjoen smelter. In exchange, Orkla received Alcoa's 45% share of Sapa Extrusions Inc. to reach 100% ownership (Alcoa Inc., 2009c).

At the end of July, Alcoa completed the sale of its interest in Rio Tinto plc to Aluminum Corp. of China (Chinalco). In February 2008, Alcoa and Chinalco had jointly acquired 12% of the stock in Rio Tinto. A change in strategy in light of the economic conditions was cited as the reason for the sale (Alcoa Inc., 2009h).

Rio Tinto sold its half of the Ningxia smelter in China to its joint-venture partner, Qingtongxia Aluminium Group Co. Ltd. in January. The smelter had a capacity of 160,000 t/yr (Rio Tinto plc, 2009a).

In February, Klesch & Co. Ltd. (London, United Kingdom) completed the acquisition of smelters at Delfzijil, Netherlands, and Voerde, Germany, from Corus Group plc (London). Each smelter had a capacity of 100,000 t/yr (Klesch and Co. Ltd., 2009).

As part of a financial restructuring deal, the Government of Montenegro received ownership of 29.4% of Kombinat Aluminijuma Podgorica and Bauxite Mines (KAP). Central European Aluminum Co. remained the managing partner of the joint venture with 29.4% ownership, with the remainder owned by other investors. Assets owned by KAP included a 120,000-t/yr smelter and a 280,000-t/yr alumina refinery at Podgorica and a 700,000-t/yr bauxite mine at Kutsko Brdo (Central European Aluminum Co., 2009, 2010).

Citing declining demand, lower prices, and lack of credit, Aleris International Inc. filed for chapter 11 bankruptcy protection in February. The secondary aluminum producer was able to continue operations through a debtor-in-possession facility. The company continued operating under bankruptcy protection throughout the year (Aleris International Inc., 2009).

Sapa Group acquired the assets of Indalex during the liquidation of Indalex. Indalex had filed for bankruptcy citing credit issues and a decline in business to automotive and construction markets. The Indalex assets in the United States included six extrusion plants and a secondary casthouse. Indalex also had five extrusion plants and a casthouse in Canada (Petersen, 2009a; Sapa Group, 2009).

World Review

Australia.—The Government of Australia was moving forward with a proposed cap-and-trade plan in an effort to reduce emissions of carbon dioxide and other greenhouse gases. The proposal included provisions for the aluminum industry and other emission-intensive industries to mitigate the cost increases during the first several years (Australian Department of Climate Change, 2009).

Alcoa and its joint-venture partners CITIC Ltd. (22.5%) and Marubeni Aluminium Australia Ltd. (22.5%) closed 53,000 t/yr of capacity at the Portland Aluminium smelter in response to declining prices and demand for aluminum. The first 15,000 t/yr of capacity was closed in December 2008, and an additional 38,000 t/yr was shut down by July 2009. The Portland smelter had a capacity of 358,000 t/yr (Alcoa Inc., 2009j).

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Huanghe Xinye Aluminum Co. completed a 250,000-t/yr smelter in Xining, Qinghai Province, and started production in June. The smelter reached full production capacity by yearend. A second potline that would increase capacity to 500,000 t/yr was proposed, but a construction schedule was not available (CRU Aluminium Monitor, 2009k).

Henan Shenhuo Group completed its 250,000-t/yr smelter expansion project in July but planned to delay commissioning because of market conditions. The project increased capacity of the smelter in Yongchen, Henan Province, to 650,000 t/yr (China Metal Market—Alumina and Aluminum, 2009h; CRU Aluminium Monitor, 2009d).

In July, Henan Linfeng Aluminum Co. completed an expansion project that increased capacity of the smelter in Linzhou, Henan Province, to 355,000 t/yr from 105,000 t/yr. The new potline was producing near full capacity by yearend (China Metal Market—Alumina and Aluminum, 2009f).

In August, Sanmenxia Tianyuan Aluminum Co. announced plans to increase production. The smelter in Sanmenxia, Henan Province, had shut down 30,000 t/yr of capacity in the last quarter of 2008 as prices declined. An expansion project that increased capacity to 140,000 t/yr from 100,000 t/yr was completed in 2009. Plans did not specify how much of the smelting capacity would be in production (Platts Metals Week, 2009h).

By the end of November, Gansu Aluminum Co. restarted its 70,000-t/yr smelter, which had been closed earlier in the year. The company was also moving forward with plans to construct a new potline at its smelter in Gansu Province by yearend 2010 with a capacity of 115,000 t/yr (CRU Aluminium Monitor, 2009j).

In February, China Guodian Corp. started construction of a smelter and captive powerplant in Pingxiang, Jiangxi Province. The smelter would have a capacity of 300,000 t/yr, and the powerplant would supply 600 MW of electricity. The project was expected to be completed in early 2012 (China Metal Market—Alumina and Aluminum, 2009e).

Xinjiang Tianlong Aluminum Co. planned to expand the capacity of the smelter in Xinjiang Province to 150,000 t/yr from 44,000 t/yr; a schedule for the project was not available (CRU Aluminium Monitor, 2009f).

France.—Production at Rio Tinto's 138,000-t/yr St. Jean de Maurienne smelter, where production cuts were implemented late in 2008 in response to declining prices, declined by 22% compared with production in 2008. Production increased during the third quarter of the year compared with that of the second quarter at the 261,000-t/yr Dunkerque smelter (Rio Tinto plc, 2009b, 2010a, p. 15).

Germany.—In January, Norsk Hydro ASA cut production at the 230,000-t/yr Neuss smelter by 30,000 t/yr as a result of falling prices and demand. The company selected the Neuss smelter for the cutback mainly because of the high cost of electricity in Germany (Norsk Hydro ASA, 2009c). During the second quarter, the production rate was reduced further to 50,000 t/yr (Norsk Hydro ASA, 2009e).

During the first quarter of the year, Trimet Aluminium AG closed 50,000 t/yr of 170,000 t/yr of capacity at the Essen smelter and 40,000 t/yr of 132,000 t/yr of capacity at the Hamburg smelter (CRU Aluminium Monitor, 2009a). At midyear, the company restarted 35,000 t/yr of capacity at the Essen smelter, as orders increased from its customers, mainly German automobile parts manufacturers (Platts Metals Week, 2009i).

Greenland.—The Government of Greenland postponed making a decision on a joint venture with Alcoa to construct a smelter and two hydroelectric powerplants to supply the smelter until at least spring 2010, citing more time to analyze the proposal and a recommendation by a labor group against taking an ownership position in the project (Jensen, 2009).

Guyana.—United Company RUSAL (Rusal) had put on hold plans to construct an alumina refinery and aluminum smelter powered by a hydroelectric plant in light of the economic conditions. Construction of the Rusal project had been scheduled to start in 2011 (Media Corp. Pte. Ltd., 2009).

Iceland.—Century announced plans to resume construction on a 360,000-t/yr smelter at Helguvik in spring 2010. Construction was halted in the fourth quarter of 2008 as a result of financing concerns. The smelter, which would be powered by a geothermal powerplant, would have four potlines, with the first potline expected to produce in early 2012 (Vaporean, 2009).

India.—National Aluminum Co. of India Ltd. (Nalco) continued with the startup of an expansion to the Angul smelter that had begun in December 2008. By July, 150 of the 240 new pots were operating, and full production was expected by yearend. The expansion increased capacity to 460,000 t/yr from 345,000 t/yr (National Aluminum Co. of India Ltd., 2009, p. 14).

Hindalco Industries Ltd. completed an expansion of the Hirakud smelter in August that increased the capacity of the smelter to 155,000 t/yr from 143,000 t/yr. The company started another expansion project that would increase capacity of the smelter to 213,000 t/yr, part of which would be completed by July 2010, and the remainder, by 2012. Hindalco continued to plan for the Aditya aluminum complex in Orissa. The complex would have a 359,000-t/yr smelter, a 1.5-Mt/yr alumina refinery, and a 900-MW captive powerplant. Funding for about one-half of the cost for the smelter and powerplant was committed. Completion of the smelter was planned for October 2011, although the refinery completion was delayed to June 2013 from January 2013. Construction of the 359,000-t/yr Mahan smelter and 900-MW powerplant was underway, with production expected to start in July 2011. Planning continued for the Jharkand smelter, but startup would be delayed until June 2013. The smelter would have a capacity of 359,000 t/yr, and a 900-MW powerplant was also being built at the site (Hindalco Industries Ltd., 2009).

Vedanta Resources plc shut down production from one 100,000-t/yr potline at the Bharat smelter during the first quarter of 2009. This shutdown followed the closure of the 38,000-t/yr Madras smelter at yearend 2008. Ramp up of the first phase of the Jharsuguda I smelter, which had started in 2008, continued through the year and was expected to reach full production capacity of 250,000 t/yr by March 2010. An expansion of the Jharsuguda I smelter, which would increase capacity to 500,000 t/yr by the end of March 2011, was under construction, and production from completed pots started in June. Construction of the Jharsuguda II smelter progressed, with initial production planned for March 2010 and full production expected in September 2011. The smelter would have a capacity of 125,000 t/yr when completed. Expansion of the Korba smelter was started, with production expected to begin in October 2010 and full production expected in 2012. The project would increase capacity to 675,000 t/yr from 350,000 t/yr (Vedanta Resources plc, 2009a, p. 13, 2009b).

Ashapura Minechem was planning to construct an aluminum complex in Rataigiri, Maharashtra. The complex would include a 500,000-t/yr alumina refinery and a 150,000-t/yr aluminum smelter with a 330-MW captive powerplant. A construction schedule was not announced (CRU Alumina Monitor, 2009a).

Anrak Aluminium Ltd. was progressing with plans to construct a 1.5-Mt/yr alumina refinery, a 250,000-t/yr aluminum smelter, and a 90-MW powerplant in Vishakhapatnam, Andhra Pradesh. A construction schedule was not available (CRU Alumina Monitor, 2009a, b).

Iran.—The Iranian Mines and Mining Industries Development and Renovation Organization (IMIDRO) opened the 147,000-t/yr Hormzal smelter in October. The new smelter was constructed in Bandar Abbas, adjacent to IMIDRO's 110,000-t/yr Almahdi smelter. IMIDRO planned to develop various downstream industries to use the aluminum (Tehran Times, 2009).

South Aluminium Co. (Salco) started construction of a 103,000-t/yr smelter east of Asalouyeh, which was expected to be completed in mid-2011. Plans called for the smelter capacity to be expanded to 310,000 t/yr at a later date. The smelter would be powered by electricity generated by natural gas from the nearby South Pars field. Salco was a joint venture between IMIDRO and Ghadir, an Iranian investment firm (Metal Bulletin, 2009).

Italy.—In November, Alcoa announced that it would temporarily close the Fusina and Portovesme smelters, owing to a ruling by the European Commission that power contracts between Alcoa and the Italian Government were out of compliance with European Union regulations. However, Alcoa continued to operate the smelters through yearend while the ruling was being appealed and solutions were discussed with the Government. The Fusina smelter had a capacity of 44,000 t/yr, and the Portovesme smelter, 150,000 t/yr (Alcoa Inc., 2009f, g).

Kazakhstan.—Construction on an expansion to increase capacity to 250,000 t/yr from 125,000 t/yr at the Pavlodar smelter continued. In December, one-half of the new pots were put into operation. Completion of the project was planned by the end of May 2010 (Eurasian Natural Resources Group Inc., 2010, p. 19).

Montenegro.—After a financial restructuring deal, Central European Aluminum Co. continued with a modernization project of the Podgorica smelter and alumina refinery expected to be completed by yearend 2010. Capacity of the smelter would increase to 156,000 t/yr from 120,000 t/yr, and capacity of the alumina refinery would increase to 400,000 t/yr from 280,000 t/yr (Central European Aluminum Co., 2009, 2010).

New Zealand.—A production cut that was implemented in mid-2008 in response to a transformer failure at the 365,000-t/yr Tiwai Point smelter was continued until mid-2009. Output from the smelter increased in the third quarter when repairs were completed (Rio Tinto plc, 2009b, 2010a, p. 15).

Nigeria.—Rusal cut production in 2009 from the Alscon smelter by 17% compared with production in 2008. The smelter was cited as having higher operating costs than other smelters owned by Rusal (United Company RUSAL, 2010).

Norway.—Production from the 171,000-t/yr smelter at Husnes was cut to 86,000 t/yr in March. Joint owners Norsk Hydro and Rio Tinto cited the decline of prices and reduced demand for the closure of the potline (Norsk Hydro ASA, 2009a).

Norsk Hydro permanently closed the 100,000-t/yr Soderberg potline at the Karmoy smelter in March. The closure was required to comply with environmental regulations and was accelerated because of the decline in the price of aluminum. The closure of the Soderberg pots left approximately 170,000 t/yr of capacity at the Karmoy smelter. All other Soderberg potlines owned by Norsk Hydro had already been closed earlier (Norsk Hydro ASA, 2009d).

Norsk Hydro temporarily closed a 100,000-t/yr potline at the 360,000-t/yr Sunndal smelter in May as a result of price declines. The company selected the 40-year-old potline at the Sunndal smelter for closure because it was the oldest and most costly potline that it still operated (Norsk Hydro ASA, 2009b).

Oman.—Ramp up continued at the 360,000-t/yr Sohar smelter that started production in June 2008, and full production was achieved by yearend 2009. The smelter was a joint venture between Abu Dhabi Water and Electric Authority, Oman Oil Co. S.A.O.C., and Rio Tinto (Rio Tinto plc, 2010a, p. 15).

Qatar.—Qatar Aluminium Ltd. (Qatalum) (a joint venture between Norsk Hydro and Qatar Petroleum Co. Ltd. in Doha) announced the first production from the smelter in Mesaieed. Although construction was still progressing in parts of the 585,000-t/yr smelter, some pots were put into operation in December, and Qatalum planned to add production as pots were completed. Completion of construction and full operation of the smelter were scheduled for the second half of 2010 (Qatar Aluminium Ltd., 2009).

Romania.—Vimetco cut production during the first quarter at the 300,000-t/yr smelter in Slatina to 240,000 t/yr as a result of price declines and reduced demand (Vimetco NV, 2009).

Russia.—An accident at the Sayano-Shushenskaya powerplant on August 17 destroyed 3 of the powerplant's 10 turbines and damaged 3 others, killing 75 workers. The powerplant was the main supplier of power to Rusal's 537,000-t/yr Sayanogorsk and 300,000-t/yr Khakas smelters, supplying a total of 3,500 MW. The powerplant also supplied some power to Rusal's smelters at Krasnoyarsk and Novokusnetsk. The effect on the smelters was minimal, and all capacity was fully operational within hours of the accident, owing to backup power being secured from other sources (Tabereaux, 2009).

Rusal cut production from its smelters in Russia by 9% compared with production in 2008 as a result of lower aluminum prices. Most of the cuts were from the Bogoslovsk, Kandalaksha, Nadvoitsy, Novokunetsk, and Urals smelters, which had higher costs than other smelters owned by Rusal in Russia. Production cuts at these smelters were made in February and ranged from 26% to 39% compared with production in 2008 (United Company RUSAL, 2010).

As a result of financing constraints, Rusal announced plans to slow construction on its Taishet smelter. The Taishet smelter would have a capacity of 750,000 t/yr and was previously planned to start production by yearend 2009, with full operation by yearend 2011 (United Company RUSAL, 2009b). The company also cut construction spending on the Boguchansky hydroelectric powerplant project and delayed full production until 2012 (CRU Aluminium Monitor, 2009b).

Rusal completed a project to increase efficiency and reduce emissions from the 1-Mt/yr Krasnoyarsk smelter in September. The smelter uses Soderberg technology, and the project was aimed at reducing atmospheric emissions of hydrocarbons and other airborne pollutants (United Company RUSAL, 2009a).

Saudi Arabia.—Alcoa and Saudi Arabian Mining Co. (Ma'aden) formed a joint venture to construct an aluminum complex with a 4.0-Mt/yr bauxite mine, a 1.8-Mt/yr alumina refinery, a 740,000-t/yr smelter, and a rolling mill. The mine would be at Al Ba'itha with bauxite transported by rail to Raz Az Zawr, where the refinery, smelter, and rolling mill would be built. Startup of the smelter and rolling mill were expected in 2013, and production from the mine and refinery would begin in 2014. Alcoa would own 20% of the operation, with Ma'aden owning 60%, and other partners owning the remaining 20% (Alcoa Inc., 2009a). Ma'aden had previously had a joint venture with Rio Tinto for the project, but Rio Tinto canceled its participation in the project amid financing constraints (Rio Tinto Alcan Inc., 2008).

South Africa.—As a result of power shortages in the country, Rio Tinto announced that plans for the proposed 720,000-t/yr Coega smelter were put on hold indefinitely. An electricity supply agreement with the state power company, Eskom, was terminated (Rio Tinto Alcan Inc., 2009b).

Sweden.—In 2009, Rusal cut production from the Kubal smelter by 38% compared with production in 2008. The smelter was cited as having higher operating costs than other smelters owned by Rusal (United Company RUSAL, 2010).

Tajikistan.—Tajik Aluminium Co. cut production from its 517,000-t/yr smelter by 40,000 t/yr in the first quarter of 2009. A power shortage and declining aluminum prices were cited as the reasons for the shutdown (Tajik Aluminium Co., 2009).

Ukraine.—In 2009, Rusal cut aluminum production from the Zaporozhye smelter by 56% compared with production in 2008. High costs were cited as the cause for the closure of the 113,000-t/yr smelter (United Company RUSAL, 2010).

United Arab Emirates.—Emirates Aluminium Ltd. announced that production had started from the first pot at its 700,000-t/yr smelter in Abu Dhabi. Work was progressing on the smelter, and full production from its 756 pots was not expected until at least December 2010. Emirates Aluminium was a partnership between Dubai Aluminium Co. Ltd. and Mubadala Development Co. (Emirates Aluminium Ltd., 2009).

United Kingdom.—The Anglesey smelter was permanently closed in September following the expiration of a power contract with a nuclear powerplant that was closing. The 150,000-t/yr smelter had been a joint venture between Kaiser Aluminum Corp. and Rio Tinto (Kaiser Aluminum Corp., 2009, p. 2).

Production at the 44,000-t/yr Lochaber, Scotland, and the 181,000-t/yr Lynemouth, England, smelters declined by 11% and 34% respectively, compared with production in 2008. Work on a modernization and expansion project of the Lochaber smelter that had been planned to begin during 2009 was deferred owing to the financial crisis (Rio Tinto plc, 2009b, 2010a).

Venezuela.—In December, power shortages forced the shutdown of two potlines totaling 50,000 t/yr of capacity at the 210,000-t/yr Alcasa smelter controlled by the state-owned Corporación Venezolana de Guayana (CVG). Starting in November, output at the Venalum smelter was also reduced slightly by reducing the amperage in the pots, but no pots were taken out of service. The country was affected by power shortages, and the Government ordered a reduction in power consumption for several industries, including aluminum smelting to avert a crisis (Platts Metals Week, 2009e, j).

Outlook

Aluminum prices generally continued their upward trend in the first half of 2010 but remained volatile. While the increased prices beginning in the second half of 2009 contributed to the restarting of some smelting capacity outside the United States, domestic smelters generally maintained production levels established during the downturn of late 2008 and early 2009. The domestic capacity that closed during the crisis was not expected to restart until producers were more confident in a sustained recovery. As of June 1, 2010, about 50% (1.75 Mt/yr) of domestic primary aluminum smelting capacity was not being used. World demand for aluminum in 2010 was expected to remain at levels lower than in 2008 owing to declines in automobile manufacturing and home construction.

Consumer credit issues in the United States and Western Europe were expected to continue through 2010. The uncertainty of the impact of sovereign debt issues in Europe also raised concerns about consumer demand. Although consumption was recovering from the decline during the crisis, decreased demand for aluminum in developed economies still recovering from the economic events of 2008 could keep global aluminum production for the 2010–2012 period below the record-high 2008 production. Demand for aluminum in emerging economies was expected to increase as these economies continue to grow and recover from the effects of the global recession. However, policies aimed at restraining construction in China may slow the rate of growth of demand for aluminum in that nation.

Lack of credit to aluminum companies was expected to continue to cause delays in expansion projects in many parts of the world, although projects in regions with low power costs were moving forward. Relatively higher electricity prices in the United States diminished the likelihood of domestic smelters reopening in the near-term. New smelters constructed where power costs are relatively low were expected to replace production at high-cost smelters in the United States and other locations.

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TABLE 1
SALIENT ALUMINUM STATISTICS[1]

		2005	2006	2007	2008	2009
United States:						
Primary production:						
Quantity	thousand metric tons	2,481	2,284	2,554	2,658	1,727
Value	millions	$4,980	$6,110	$6,880	$7,060	$3,030
Price, average, U.S. market, spot	cents per pound	91.0	121.4	122.2	120.5	79.4
Inventories (December 31):						
Aluminum industry[2]	thousand metric tons	1,430	1,410	1,400	1,220 r	937
London Metal Exchange, U.S. warehouses[3]	do.	209	228	463	1,290	2,200
Secondary recovery:[4]						
New scrap	do.	1,950	2,290 r	2,250 r	1,960 r	1,520
Old scrap	do.	1,080	1,260 r	1,540 r	1,370 r	1,190
Total	do.	3,030	3,540	3,790 r	3,330 r	2,710
Exports, crude and semicrude	do.	2,370	2,820	2,840	3,280	2,710
Imports for consumption, crude and semicrude[5]	do.	4,850 r	4,660 r	4,020 r	3,710 r	3,680
Supply, apparent[6]	do.	8,480 r	8,190 r	7,990 r	6,900 r	5,840
Consumption, apparent[7]	do.	6,530 r	5,900 r	5,740 r	4,940 r	4,320
World, production	do.	31,900	33,900	38,100 r	39,600 r	37,300 e

[e]Estimated. [r]Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits except "Primary production: Quantity" and "Price, average, U.S. market, spot."

[2] Data from the Aluminum Association Inc.; includes ingot, semifabricated material, and scrap inventory levels for United States and Canadian producers.

[3] Includes aluminum alloyed material.

[4] Metallic recovery from purchased, tolled, or imported new and old scrap expanded for full industry coverage.

[5] Excludes scrap.

[6] Defined as domestic primary metal production plus secondary recovery plus imports minus exports plus adjustments for government and industry stock changes.

[7] Apparent supply less recovery from purchased new scrap.

TABLE 2
PRIMARY ANNUAL ALUMINUM PRODUCTION CAPACITY IN THE UNITED STATES, BY COMPANY[1]

Company and location	Yearend capacity (thousand metric tons) 2008	Yearend capacity (thousand metric tons) 2009	Ownership in 2009
Alcoa Inc.:			
Alcoa, TN[2]	215	215	Alcoa Inc., 100%.
Badin, NC[2]	120	120	Do.
Evansville, IN (Warrick)	309	309	Do.
Ferndale, WA (Intalco)	278	278	Do.
Frederick, MD (Eastalco)[2]	195	195	Do.
Massena, NY (St. Lawrence)[2]	125	125	Do.
Massena, NY	130	130	Do.
Mount Holly, SC	224	224	Alcoa Inc., 50.3%; Century Aluminum Co., 49.7%.
Rockdale, TX[2]	267	267	Alcoa Inc., 100%.
Wenatchee, WA	184	184	Do.
Total	2,050	2,050	

See footnotes at end of table.

TABLE 2—Continued

PRIMARY ANNUAL ALUMINUM PRODUCTION CAPACITY IN THE UNITED STATES, BY COMPANY[1]

Company and location	Yearend capacity (thousand metric tons) 2008	2009	Ownership in 2009
Century Aluminum Co.:			
Hawesville, KY	244	244	Century Aluminum Co., 100%.
Ravenswood, WV[2]	170	170	Do.
Total	414	414	
Columbia Falls Aluminum Co., Columbia Falls, MT[2]	168	168	Glencore International AG, 100%.
Goldendale Aluminum Co., Goldendale, WA[2]	160	160	Private interest, 60%; employees, 40%.
Noranda Aluminum Holding Corp., New Madrid, MO	250	250	Apollo Management LP, 100%.
Ormet Primary Aluminum Corp., Hannibal, OH	265	265	Ormet Corp., 100%.
Rio Tinto Alcan Inc., Sebree, KY	196	196	Rio Tinto Alcan Inc., 100%.
Vanalco Inc., Vancouver, WA[3]	116	--	Glencore International AG, 100%.
Grand total	3,620	3,500	

Do. Ditto. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Idle.

[3] Demolition of smelter facilities completed in 2009.

TABLE 3

U.S. CONSUMPTION OF AND RECOVERY FROM PURCHASED NEW AND OLD ALUMINUM SCRAP, BY CLASS[1, 2]

(Metric tons)

Class	Consumption	Calculated recovery Aluminum	Metallic
2008:			
Secondary smelters	1,580,000	1,040,000 [r]	1,110,000 [r]
Independent mill fabricators[3]	2,180,000	1,800,000	1,910,000
Foundries	77,300	63,300	67,700
Other consumers	8,760	7,770	7,800
Total	3,850,000	2,910,000 [r]	3,090,000
Estimated full industry coverage[r]	4,150,000	3,130,000	3,330,000
2009:			
Secondary smelters	1,090,000	782,000	836,000
Independent mill fabricators[3]	1,870,000	1,530,000	1,620,000
Foundries	74,800	61,200	65,400
Other consumers	6,870	6,330	6,350
Total	3,040,000	2,380,000	2,530,000
Estimated full industry coverage	3,260,000	2,540,000	2,710,000

[r] Revised.

[1] Excludes recovery from other than aluminum-base scrap.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Includes plants previously categorized as "Integrated aluminum companies."

TABLE 4

U.S. STOCKS, RECEIPTS, AND CONSUMPTION OF PURCHASED NEW AND OLD ALUMINUM SCRAP AND SWEATED PIG IN 2009[1, 2]

(Metric tons)

Class of consumer and type of scrap	Stocks, January 1	Net receipts[3]	Consumption	Stocks, December 31
Secondary smelters:				
New scrap:				
Extrusions	16,300 r	243,000	244,000	15,400
Can stock clippings	2,800	51,900	52,500	2,250
Other wrought sheet and clippings	1,300 r	140,000	140,000	1,090
Casting	711	31,800	31,900	588
Borings and turnings	1,170 r	62,500	62,600	1,110
Dross and skimmings	667	275,000	276,000	332
Total	22,900 r	805,000	807,000	20,800
Old scrap:				
Castings	1,670 r	92,600	93,100	1,150
Extrusion	1,560 r	49,400	49,400	1,530
Aluminum cans[4]	--	38,700	38,700	--
Other wrought products	1,620 r	50,100	50,000	1,690
Auto shredder scrap	965 r	49,700	49,800	864
Total	5,810 r	280,000	281,000	5,230
Sweated pig	1	1,520	1,420	106
Grand total secondary smelters	28,700 r	1,090,000	1,090,000	26,100
Integrated aluminum companies, foundries, independent mill fabricators, other consumers:				
New scrap:				
Extrusion	7,090 r	457,000	450,000	14,900
Can stock clippings	982	184,000	183,000	1,280
Other wrought sheet and clippings	4,620	115,000	116,000	4,240
Casting	243	33,100	32,800	462
Borings and turnings	470 r	28,800	28,100	1,170
Dross and skimmings	1,660 r	136,000	131,000	7,150
Total	15,100	954,000	940,000	29,200
Old scrap:				
Castings	8,780	107,000	111,000	5,270
Extrusion	1,530	24,500	24,200	1,860
Aluminum cans[4]	8,150	633,000	630,000	11,800
Other wrought products	3,590	120,000	119,000	4,900
Auto shredder scrap	82	454	454	82
Other	--	125,000	125,000	--
Total	22,100	1,010,000	1,010,000	23,900
Sweated pig	--	--	--	--
Grand total integrated aluminum companies, etc.	37,200	1,970,000	1,950,000	53,100
All scrap consumed:				
New scrap:				
Extrusion	23,400 r	701,000	694,000	30,300
Can stock clippings	3,780	236,000	236,000	3,530
Other wrought sheet and clippings	5,920 r	255,000	256,000	5,330
Casting	954	64,800	64,700	1,050
Borings and turnings	1,640 r	91,300	90,600	2,280
Dross and skimmings	2,330 r	412,000	406,000	7,480
Total	38,000 r	1,760,000	1,750,000	50,000
Old scrap:				
Castings	10,400 r	200,000	204,000	6,420
Extrusion	3,090 r	73,900	73,600	3,390
Aluminum cans[4]	8,150	672,000	669,000	11,800
Other wrought products	5,210	170,000	169,000	6,590
Auto shredder scrap	1,050	50,200	50,300	946
Other	--	125,000	125,000	--
Total	27,900 r	1,290,000	1,290,000	29,100
Sweated pig	1	1,520	1,420	106
Grand total all scrap consumed	65,900 r	3,050,000	3,040,000	79,200

See footnotes at end of table.

TABLE 4—Continued

U.S. STOCKS, RECEIPTS, AND CONSUMPTION OF PURCHASED NEW AND OLD ALUMINUM SCRAP AND SWEATED PIG IN 2009[1, 2]

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[r] Revised. -- Zero.

[1] Includes imported scrap. According to reporting companies, 5.60% of total receipts of aluminum-base scrap, or 172,000 metric tons, was received on toll arrangements.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Includes inventory adjustment.

[4] Used beverage cans toll treated for primary producers are included in secondary smelter tabulation.

TABLE 5

PRODUCTION AND SHIPMENTS OF SECONDARY ALUMINUM ALLOYS BY INDEPENDENT SMELTERS IN THE UNITED STATES[1]

(Metric tons)

	2008		2009	
	Production	Net shipments[2]	Production	Net shipments[2]
Diecast alloys:				
13% Si, 360, etc. (0.6% Cu, maximum)	16,300 [r]	16,500 [r]	35,900	35,900
380 and variations	166,000 [r]	165,000 [r]	87,200	88,400
Sand and permanent mold:				
95/5 Al-Si, 356, etc. (0.6% Cu, maximum)	28,600 [r]	28,200 [r]	35,700	35,000
No. 12 and variations	2,020	2,020	907	907
No. 319 and variations	60,000 [r]	60,000 [r]	31,900	31,300
F-132 alloy and variations	14,700 [r]	14,400 [r]	6,010	5,990
Al-Mg alloys	8,170 [r]	8,300 [r]	7,220	7,170
Al-Zn alloys	1,650	1,560	1,560	1,580
Al-Si alloys (0.6% to 2.0% Cu)	11,000 [r]	10,900 [r]	2,730	2,590
Al-Cu alloys (1.5% Si, maximum)	521	484	468	468
Al-Si-Cu-Ni alloys	10,100 [r]	9,510 [r]	5,870	5,870
Other	162	205	136	136
Wrought alloys, extrusion billets	467,000 [r]	466,000 [r]	372,000	378,000
Miscellaneous:				
Steel deoxidation	39,900	39,900	19,700	19,600
Pure (97.0% Al)	W	W	W	W
Aluminum-base hardeners	W	W	W	W
Other[3]	60,400 [r]	60,500 [r]	51,500	48,800
Total	886,000 [r]	884,000 [r]	659,000	662,000
Less consumption of materials other than scrap:				
Primary aluminum	109,000 [r]	XX	96,600	XX
Primary silicon	11,500 [r]	XX	11,400	XX
Other	7,410 [r]	XX	9,160	XX
Net metallic recovery from aluminum scrap and sweated pig consumed in production of secondary aluminum ingot[4]	758,000 [r]	XX	542,000	XX

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous, other." XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes inventory adjustment.

[3] Includes other diecast alloys.

[4] No allowance made for melt loss of primary aluminum and alloying ingredients.

TABLE 6
DISTRIBUTION OF END-USE SHIPMENTS OF ALUMINUM PRODUCTS IN THE UNITED STATES AND CANADA, BY INDUSTRY[1]

Industry	2008 Quantity (thousand metric tons)	2008 Percentage of grand total	2009[p] Quantity (thousand metric tons)	2009[p] Percentage of grand total
Containers and packaging	2,240 [r]	22.3 [r]	2,150	26.5
Building and construction	1,180	11.7	964	11.9
Transportation	2,830	28.1	1,910	23.7
Electrical	700	7.0	593	7.3
Consumer durables	607	6.0	458	5.7
Machinery and equipment	688	6.8 [r]	475	5.9
Other markets	334	3.3	254	3.1
Total	8,570 [r]	85.2	6,810	84.1
Exports[e]	1,490	14.8	1,280	15.9
Grand total	10,100 [r]	100.0	8,090	100.0

[e] Estimated. [p] Preliminary. [r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: The Aluminum Association Inc.

TABLE 7
U.S. NET SHIPMENTS OF ALUMINUM WROUGHT AND CAST PRODUCTS, BY PRODUCERS[1, 2]

(Thousand metric tons)

	2007	2008	2009[p]
Wrought products[3]:			
Sheet, plate, foil	5,000 [r]	4,770 [r]	4,050
Pipe, tube, extruded shapes	1,580 [r]	1,380 [r]	1,070
Rod, bar, wire, cable	688 [r]	626 [r]	514
Forgings (including impacts)	132 [r]	102 [r]	73
Powder, flake, paste	68 [r]	61 [r]	45
Total	7,470 [r]	6,940 [r]	5,750
Castings:			
Sand	315	255 [r]	160
Permanent and semipermanent mold	615	570	371
Die	1,260	1,030	691
Other	35	44	6
Total	2,230	1,900	1,230
Grand total	9,690 [r]	8,830 [r]	6,990

[p] Preliminary. [r] Revised.

[1] Net shipments derived by subtracting the sum of producers' domestic receipts of each mill shape from the domestic industry's gross shipments of that shape.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Wrought products data series includes net shipments in both the United States and Canada.

Source: The Aluminum Association Inc.

TABLE 8
ALUMINUM PRICES

(Dollars per pound)

Material	2008	2009
Primary aluminum, average:[1]		
U.S. market	1.205	0.794
LME cash price	1.167	0.755
NASAAC cash price, average	1.021	0.659
Secondary alloy, yearend:[2]		
A319 (3% Cu)	0.725	1.055
A380 (3% Zu)	0.665	1.005
A360 (0.6% Cu)	0.715	1.065
A413 (0.6%Cu)	0.715	1.065
Scrap, yearend:[2]		
Clean, dry turnings	0.33–0.34	0.60–0.61
Mixed low-copper-content clips	0.37–0.38	0.67–0.68
Old sheet and castings	0.34–0.35	0.62–0.63
Used beverages cans	0.44–0.46	0.71–0.73

[1] Source: Platts Metals Week.

[2] Source: American Metal Market.

TABLE 9
U.S. EXPORTS OF ALUMINUM, BY CLASS[1]

	2008		2009	
Class	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	308,000	$890,000	262,000	$514,000
Scrap	1,980,000	3,420,000	1,660,000	2,120,000
Plates, sheets, bars, strip, etc.	929,000	4,020,000	739,000	2,830,000
Castings and forgings	24,400	304,000	18,900	218,000
Semifabricated forms, n.e.c.	39,500	385,000	31,100	226,000
Total	3,280,000	9,020,000	2,710,000	5,910,000
Manufactures:				
Foil and leaf	89,700	436,000	72,000	323,000
Powders and flakes	7,840	39,600	4,470	24,100
Wire and cable	52,900	207,000	45,900	132,000
Total	150,000	683,000	122,000	479,000
Grand total	3,430,000	9,710,000	2,830,000	6,390,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 10

U.S. EXPORTS OF ALUMINUM, BY COUNTRY[1]

	Metals and alloys, crude		Plates, sheets, bars, etc.[2]		Scrap		Total	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2008:								
Brazil	400	$1,120	9,820	$63,800	4,300	$10,200	14,500	$75,100
Canada	103,000	287,000	413,000	1,680,000	161,000	336,000	678,000	2,300,000
China	1,020	2,450	41,300	302,000	893,000	1,740,000	936,000	2,050,000
France	749	3,140	10,900	99,000	113	500	11,800	103,000
Germany	2,780	12,100	10,700	74,400	1,210	2,890	14,700	89,300
Hong Kong	203	736	17,000	79,200	94,700	195,000	112,000	275,000
Italy	36	160	3,320	42,400	429	950	3,780	43,500
Japan	9,360	34,600	20,300	182,000	59,100	130,000	88,700	346,000
Korea, Republic of	865	2,160	16,300	115,000	223,000	387,000	240,000	505,000
Mexico	178,000	507,000	266,000	1,080,000	85,800	185,000	530,000	1,770,000
Netherlands	421	1,750	1,860	20,100	1,320	2,990	3,600	24,900
Russia	--	--	126	1,090	--	--	126	1,090
Saudi Arabia	264	519	43,400	193,000	18	8	43,700	194,000
Singapore	313	1,050	1,450	15,300	691	942	2,450	17,300
Taiwan	84	592	8,360	48,700	321,000	277,000	330,000	327,000
Thailand	256	383	12,100	47,600	72,800	63,800	85,200	112,000
Ukraine	--	--	14	84	--	--	14	84
United Kingdom	1,100	5,710	24,300	175,000	849	2,580	26,300	183,000
Venezuela	42	182	772	4,450	502	769	1,320	5,410
Other	8,830	29,600	91,800[r]	488,000[r]	61,700	86,100	162,000	604,000[r]
Total	308,000	890,000	993,000	4,710,000	1,980,000	3,420,000	3,280,000	9,020,000
2009:								
Brazil	59	449	11,900	66,500	5,360	7,130	17,300	74,100
Canada	69,600	135,000	300,000	1,010,000	107,000	169,000	476,000	1,310,000
China	21,600	31,900	38,400	215,000	1,010,000	1,260,000	1,070,000	1,510,000
France	710	2,830	9,240	63,100	3	11	9,950	66,000
Germany	4,860	12,800	9,820	72,000	326	743	15,000	85,500
Hong Kong	1,620	3,880	9,090	36,600	76,800	111,000	87,500	151,000
Italy	1,170	4,320	2,370	26,100	--	--	3,540	30,400
Japan	10,500	19,600	8,650	95,500	21,100	31,800	40,200	147,000
Korea, Republic of	1,870	3,930	10,900	80,800	160,000	197,000	173,000	282,000
Mexico	123,000	243,000	249,000	915,000	91,600	148,000	464,000	1,310,000
Netherlands	97	599	711	9,890	315	407	1,120	10,900
Russia	3	36	113	993	--	--	116	1,030
Saudi Arabia	238	606	26,100	123,000	--	--	26,400	124,000
Singapore	16,500	32,400	1,440	13,300	421	586	18,400	46,300
Taiwan	2,460	4,240	2,910	20,400	100,000	103,000	106,000	128,000
Thailand	115	234	7,990	28,900	5,940	7,890	14,000	37,000
Ukraine	--	--	6	59	22	13	27	72
United Kingdom	769	3,440	10,000	93,000	572	1,720	11,400	98,100
Venezuela	41	546	361	2,270	718	1,000	1,120	3,820
Other	6,440	14,800	90,500	400,000	80,300	82,300	177,000	497,000
Total	262,000	514,000	789,000	3,270,000	1,660,000	2,120,000	2,710,000	5,910,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes castings, forgings, and unclassified semifabricated forms.

Source: U.S. Census Bureau.

TABLE 11

U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM, BY CLASS[1]

Class	2008		2009	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	2,790,000	$7,810,000	2,900,000	$4,960,000
Plates, sheets, strip, etc., n.e.c.[2]	693,000	2,770,000	499,000	1,550,000
Pipes, tubes, etc.	34,200	271,000	33,400	190,000
Rods and bars	186,000	825,000	254,000	783,000
Scrap	494,000	853,000	433,000	503,000
Total	4,200,000	12,500,000	4,110,000	7,980,000
Manufactures:				
Foil and leaf[3]	130,000	590,000	102,000	389,000
Powders and flakes	9,150	43,000	5,710	22,200
Wire	185,000	574,000	156,000	321,000
Total	325,000	1,210,000	264,000	732,000
Grand total	4,530,000	13,700,000	4,380,000	8,710,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes circles, disks, plates, and sheets.

[3] Excludes etched capacitor foil.

Source: U.S. Census Bureau.

TABLE 12

U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM, BY COUNTRY[1]

Country	Metals and alloys, crude		Plates, sheets, bars, etc.[2]		Scrap		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2008:								
Argentina	90,000	$259,000	--	--	--	--	90,000	$259,000
Australia	39,900	117,000	120	$1,350	109	$240	40,100	119,000
Bahrain	8,930	26,700	18,200	63,400	--	--	27,100	90,100
Belgium	87	468	4,790	24,700	--	--	4,880	25,100
Brazil	82,500	226,000	13,800	45,900	367	650	96,700	273,000
Canada	1,990,000	5,510,000	379,000	1,450,000	330,000	558,000	2,700,000	7,520,000
China	21,900	63,200	151,000	567,000	33	70	173,000	630,000
France	511	8,500	4,140	35,700	799	1,180	5,450	45,400
Germany	2,460	7,320	88,500	488,000	386	1,410	91,300	496,000
Italy	32	171	6,120	38,000	18	32	6,170	38,200
Japan	1,030	2,180	10,700	61,300	818	4,960	12,500	68,400
Korea, Republic of	909	2,970	2,010	10,400	184	548	3,100	13,900
Mexico	23,900	109,000	17,800	99,000	114,000	196,000	155,000	405,000
Netherlands	1,130	3,560	2,330	16,500	191	421	3,650	20,500
Norway	2,710	8,750	14	172	--	--	2,720	8,920
Panama	151	384	--	--	2,410	4,860	2,570	5,250
Russia	288,000	795,000	45,900	202,000	1,490	4,380	335,000	1,000,000
Slovenia	--	--	3,550	18,000	--	--	3,550	18,000
South Africa	9,440	23,700	40,100	156,000	500	190	50,000	180,000
Spain	161	715	149	1,310	8	31	318	2,060
Tajikstan	2,780	7,020	--	--	--	--	2,780	7,020
United Arab Emirates	80,300	241,000	19	73	278	518	80,600	241,000
United Kingdom	1,760	3,930	7,930	46,600	6,460	12,900	16,200	63,400
Venezuela	103,000	282,000	3,690	10,700	2,500	5,420	110,000	298,000
Other	38,000	108,000	114,000	531,000	33,500	60,900	185,000	700,000
Total	2,790,000	7,810,000	914,000	3,860,000	494,000	853,000	4,200,000	12,500,000

See footnotes at end of table.

TABLE 12—Continued
U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM, BY COUNTRY[1]

Country	Metals and alloys, crude		Plates, sheets, bars, etc.[2]		Scrap		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009:								
Argentina	164,000	$269,000	2	$32	--	--	164,000	$269,000
Australia	7,500	13,600	44	581	--	--	7,550	14,200
Bahrain	1,690	4,400	9,860	28,100	--	--	11,600	32,500
Belgium	178	685	2,180	9,540	26	$56	2,380	10,300
Brazil	106,000	183,000	15,000	33,500	--	--	121,000	216,000
Canada	2,020,000	3,490,000	261,000	772,000	293,000	328,000	2,570,000	4,590,000
China	1,890	3,570	250,000	668,000	9	39	252,000	672,000
France	1,520	8,970	1,710	17,800	35	335	3,260	27,100
Germany	579	2,270	61,200	309,000	413	883	62,200	312,000
Italy	(3)	23	3,540	21,300	97	79	3,630	21,400
Japan	492	1,210	8,900	42,900	414	1,340	9,800	45,400
Korea, Republic of	2,330	4,000	1,580	7,430	105	157	4,010	11,600
Mexico	18,400	68,800	13,400	63,000	95,700	120,000	128,000	252,000
Netherlands	210	859	1,560	9,780	2,150	2,800	3,920	13,400
Norway	442	926	14	412	--	--	457	1,340
Panama	197	298	--	--	1,640	1,830	1,840	2,120
Russia	353,000	548,000	16,700	67,300	1,740	2,970	371,000	618,000
Slovenia	--	--	1,440	6,390	--	--	1,440	6,390
South Africa	52,900	76,000	37,800	97,700	27	28	90,700	174,000
Spain	131	502	121	1,110	--	--	252	1,610
Tajikstan	6,690	8,260	--	--	--	--	6,690	8,260
United Arab Emirates	48,300	93,800	--	--	16	18	48,300	93,900
United Kingdom	355	1,290	4,760	24,000	8,840	9,280	14,000	34,600
Venezuela	84,400	131,000	6,250	10,700	8,390	12,700	99,100	155,000
Other	23,700	42,700	88,600	328,000	20,300	22,200	133,000	393,000
Total	2,900,000	4,960,000	786,000	2,520,000	433,000	503,000	4,110,000	7,980,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes circles, disks, pipes, rods, tubes, etc.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 13
ALUMINUM, PRIMARY: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2005	2006	2007	2008	2009[e]
Argentina	271	273	271	394 [r]	400
Australia	1,903	1,932	1,957	1,974	1,943 [3]
Azerbaijan	32	32	39	40	30
Bahrain	751	872	865	872 [r]	870
Bosnia and Herzegovina[4]	131	136	122	123 [e]	96
Brazil	1,499	1,605	1,655	1,661	1,536 [3]
Cameroon	90	88 [e]	87	91	73 [3]
Canada	2,894	3,051	3,083	3,120	3,030 [3]
China[e]	7,800	9,360	12,600	13,200	12,900
Egypt	244	252	258	260	265
France	442	442	428	389	345 [3]

See footnotes at end of table.

TABLE 13—Continued

ALUMINUM, PRIMARY: WORLD PRODUCTION, BY COUNTRY[1,2]

(Thousand metric tons)

Country	2005	2006	2007	2008	2009[e]
Germany	648	516	551	606 [r]	292 [3]
Ghana	13	8	--	--	--
Greece	165	163	166	160	160
Hungary[e]	31	34	--	--	--
Iceland[5]	272	320	398	787	785
India[6]	942	1,105	1,222	1,308	1,400
Indonesia[6]	252	250	242	243	250
Iran[e]	220	205	216 [r]	248 [r]	250
Italy	193	194	183	180 [r, e]	180
Japan[7]	7	7	7 [e]	7	7
Kazakhstan	--	--	--	106 [r]	127 [3]
Montenegro	117 [8]	122	124 [r]	107 [r]	64 [3]
Mozambique	555	564	564	536	545 [3]
Netherlands	325	312	301	301 [e]	300
New Zealand	351	337	353	316	271 [3]
Nigeria	--	--	--	11 [r]	13 [3]
Norway	1,372	1,331	1,357	1,358	1,130
Oman	--	--	--	49	351 [3]
Poland[9]	55	58	59	48 [r]	47
Qatar	--	--	--	--	10
Romania[10]	239 [r]	256 [r]	283 [r]	265 [r]	229
Russia	3,647	3,718	3,955	4,190 [r]	3,815 [3]
Slovakia[6]	162 [r]	158 [r]	160 [r]	163 [r]	150
Slovenia[4]	139	118	111	83 [r]	85
South Africa	846	931	914	811	809
Spain	394	349	408 [r]	408 [r, e]	408 [p]
Sweden	102	101	98	112 [r]	70 [3]
Switzerland	45	12	--	--	--
Tajikistan	380	414	419	339	359 [3]
Turkey[e]	60	60	65	65	65
Ukraine[10]	114	113	113	113	50
United Arab Emirates	722 [e]	861	890	948 [r]	1,010
United Kingdom	369	360	365	326	253 [3]
United States	2,481	2,284	2,554	2,658	1,727 [3]
Venezuela[e]	615 [3]	610	610	610	610
Total	31,900	33,900	38,100 [r]	39,600 [r]	37,300

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Primary aluminum is defined as "The weight of liquid aluminum as tapped from pots, excluding the weight of any alloying materials as well that of any metal produced from either returned scrap of remelted material." International reporting practices vary from country to country, some nations conforming to the foregoing definition and others using different definitions. For those countries for which a different definition is given specifically in the source publication, that definition is provided in this table by footnote. Table includes data available through March 29, 2010.

[3] Reported figure.

[4] Primary ingot plus secondary ingot.

[5] Ingot and rolling billet production.

[6] Primary ingot.

[7] Excludes high purity aluminum containing 99.995% or more as follows, in metric tons: 2005—45,400; 2006—49,700; 2007—50,800 (revised); 2008—51,000 (revised); and 2009—52,000 (estimated).

[8] Montenegro and Serbia formally declared independence in June 2006, from each other and dissolved their union.

[9] Primary unalloyed ingot plus secondary unalloyed ingot.

[10] Primary unalloyed metal plus primary alloyed metal, thus including weight of alloying material.

ANTIMONY

By James F. Carlin, Jr.

Domestic survey data and tables were prepared by Shonta E. Osborne, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

A single company in the United States, in Montana, produced primary antimony metal and antimony oxide by upgrading imported antimony trioxide to a higher purity. Secondary antimony was recovered in lead alloy from scrapped lead-acid batteries at secondary lead smelters. The amount of antimony used by battery manufacturers was substantially lower than it was 10 years ago because of changing material requirements for batteries.

In 2009, about 35% of the primary antimony used in the United States went into flame retardants; most of the rest was used by the ceramic, chemical, glass, and transportation industries (table 3). Secondary antimony, which was derived almost entirely from recycled lead-acid batteries and contained in antimonial lead, was used in the manufacture of new batteries.

Antimony was mined as a principal product or was a byproduct of the smelting of base-metal ores in 10 countries. Nearly all the world's primary antimony was mined in China (91%). Bolivia, Russia, and South Africa each produced about 2% of world production (table 9).

Production

Mine.—Stockpile Reserves LLC (Lovelock, NV) had no production in 2009 from its reactivated Fencemaker Mine, 80 kilometers southeast of Lovelock. The mine produced a small amount of antimony-in-concentrate in 2007, which was the first domestic antimony mine production since 2000. The mine had a long history of intermittent antimony production dating back to the 1880s. Stockpile Reserves continued to seek additional funding and to cooperate with the Nevada regulatory authorities about required licenses and permits (Richard E. Brown, chief executive officer, Stockpile Reserves LLC, written commun., November 23, 2010).

Silverado Gold Mines Ltd. (Vancouver, British Columbia, Canada) reported promising results at its Nolan Creek gold-antimony prospect in northern Alaska. Earlier investigations had established that the Workman's Bench deposit contained probable mineral reserves of 42,400 metric tons (t) grading 28% antimony. In 2009, Silverado conducted additional drilling in the Pringle Bench and the Workman's Bench deposits in an effort to increase gold and antimony resource potential. The company will be evaluating the findings (Silverado Gold Mines Ltd., 2009).

Smelter.—The United States has only one antimony smelter, U.S. Antimony Corp. (USAC) (Thompson Falls, MT). USAC produced antimony metal for bearings, lead alloys, and ordnance; antimony oxide as a raw material for flame retardants; and sodium antimonite for glass and other applications. USAC also recycled antimony-containing products that would otherwise be taken to landfill sites.

Consumption

Of the 132 companies to which a U.S. Geological Survey antimony consumption survey was sent, 61 firms responded, representing 51% of the data reported in table 2. Consumption data were estimated for the remaining 71 firms.

In 2009, consumption (reported and estimated) of primary antimony decreased by 17% from that in 2008 (table 2). The metal products usage category experienced a notable increase, the nonmetal products category notched a moderate decrease, and the flame retardants sector showed a major decrease, which resulted from the economic slowdown (table 3).

Lead-antimony alloys were used in ammunition, antifriction bearings, cable sheaths, corrosion-resistant pumps and pipes, roof sheet solder, and tank lining. Antimony trioxide was used to enhance the flame-retardant properties of plastics, rubber and textiles, and other combustibles. Antimony was also used as a decolorizing and refining agent in the manufacture of some forms of glass, such as optical glass.

Prices

In 2009, the average price of antimony was $2.36 per pound, a decrease of 16% compared with that in 2008 (table 1). Antimony prices started the year at $1.93 per pound and rose slowly during the year to finish December at $2.90 per pound. Industry sources attributed the price increase to a marked decrease in world antimony mine output.

Foreign Trade

U.S. imports of antimony in 2009 were, as has been the case in the recent past, much larger than exports—about 10-fold larger (tables 5–8). Imports of antimony were 20,200 t, a decrease of 30% from that in 2008. China was the leading supplier to the United States of antimony metal and antimony oxide, and Bolivia was the leading supplier of antimony ore and antimony concentrate (tables 7–8).

World Review

Australia.—Anchor Resources Ltd. (Sydney, New South Wales) completed an access agreement with a local landowner to allow exploration to start at its Bielsdown antimony project (formerly Wild Cattle Creek antimony mine) in New South Wales. The company completed a 10-hole drilling program in May (Anchor Resources Ltd., 2009, p. 3).

Canada.—Hunan Nonferrous Metals Corp. (HNC) (Changsa, Hunan Province, China), an integrated metals producer, agreed to acquire a 100% equity interest in Beaver Brook Antimony Mine Inc. (Gander, Newfoundland), one of the relatively few operating antimony producers outside of China. The 550-metric-ton-per-day (t/d) underground mine has an estimated lifespan of 10 years (Riley, 2009).

China.—Chenzhou Mining Group Co., Ltd. (Guanzhuang, Yuanling Province) acquired the Zhazixi Antimony Mine (Anhua, Hunan Province). Zhazixi has a production capacity of 150,000 metric tons per year (t/yr) of antimony ore, and also has a production capacity to produce 3,000 t/yr of refined antimony (China Metal Market—Precious & Minor Metals, 2009).

The Government of China announced changes in its export quotas for antimony and several other metals for 2009. The 2009 export quota for antimony and antimony products was 58,700 t, compared with 59,900 t in 2008 (Platts Metals Week, 2008).

Hsikwangshan Twinkling Star Co. Ltd. (Lengshuijiang, Hunan Province) suspended production at its underground antimony mines in southeast-central China following an accident in October that left 26 people dead. The accident was at Hsikwangshan's main mine, and all underground mining was halted. The accident occurred after the brakes in two of the mine's lifts malfunctioned. The company was the world's leading producer of antimony, with an ore production capacity of 55,000 t/yr and 40,000 t/yr of antimony products. The lack of normal production from the important mine contributed to the surge in antimony prices in 2009 (Wallop, 2009).

Mexico.—USAC received permits to construct and operate an antimony concentrating mill in Mexico after a 3-year wait. The site of the new mill in Queretaro was close to USAC's existing Mexican antimony and silver properties and antimony smelter. USAC intended to transport its prefabricated flotation mill from its base in Montana and assemble it in Mexico to begin an initial production of 150 t/d of feed in early 2010. USAC anticipated that each metric ton of mill feed may contain 17 kilograms (kg) of antimony and 0.25 kg of silver. The mill site offered USAC the potential to increase the mill capacity of antimony and antimony oxide severalfold in the future (Industrial Minerals, 2009).

Outlook

The use of antimony as an ingredient in flame retardants was expected to remain its principal use, for global as well as for U.S. markets.

Antimony recovered from scrap has long been an important part of the total antimony supply domestically, but the recovery decline during the past 30 or more years is expected to continue, though at a more moderate rate. Following the advent in the 1970s of low-maintenance and maintenance-free automotive batteries, the antimony content of a typical automotive lead-acid battery in 2009 had fallen to about 0.6% or lower.

In recent years, lead-acid battery manufacturers have initiated research and development programs that could ultimately lead to significant changes in lead-acid battery design. This research has already yielded performance improvements that would make lead-acid batteries viable options for future generation vehicles. The introduction of new lead-acid battery technologies for use in the hybrid vehicle market will likely require a different amount of lead per battery than conventional lead-acid batteries and could eventually reduce or eliminate the use of antimony in lead-acid batteries.

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TABLE 1
SALIENT ANTIMONY STATISTICS[1]

(Metric tons of antimony content unless otherwise specified)

		2005	2006	2007	2008	2009
United States:						
Mine production		--	--	W	--	--
Smelter production:						
Primary		W	W	W	W	W
Secondary		3,620 [r]	3,520	3,480	3,180 [r]	3,020
Exports:						
Metal, alloys, waste and scrap	gross weight	740	459	305	366	385
Antimony oxide[2]		1,400	1,680	1,640	1,830	1,710
Imports for consumption		22,700	23,200	21,900	29,000	20,200
Reported industrial consumption, primary antimony		9,140	10,400	9,590	8,140 [r]	6,770
Stocks, primary antimony, all classes, December 31		2,110	2,120	1,900	1,490 [r]	1,420
Price, average[3]	cents per pound	160.5	238.0	257.3	279.5	235.6
World, mine production		172,000	173,000 [r]	180,000	182,000 [r]	155,000 [e]

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Antimony content is calculated by the U.S. Geological Survey.

[3] New York dealer price for 99.5% to 99.6% metal, cost, insurance, freight U.S. ports.

TABLE 2
REPORTED INDUSTRIAL CONSUMPTION OF PRIMARY ANTIMONY IN THE UNITED STATES[1]

(Metric tons of antimony content)

Class of material consumed	2008	2009
Metal	1,380	1,160
Oxide	6,100 [r]	5,000
Other[2]	663 [r]	616
Total	8,140 [r]	6,770

[r] Revised.

[1] Data are rounded to no more than three significant digits: may not add to totals shown.

[2] Includes residues and sulfide.

TABLE 3
REPORTED INDUSTRIAL CONSUMPTION OF PRIMARY ANTIMONY IN THE UNITED STATES, BY PRODUCT[1]

(Metric tons of antimony content)

Product	2008	2009
Metal products:		
Antimonial lead	W	W
Bearing metal and bearings	18	14
Solder	54	44
Other[2]	1,610	1,950
Total	1,690	2,000
Nonmetal products:		
Ammunition primers	W	W
Ceramics and glass	259	W
Pigments	448	403
Plastics	W	W
Other[3]	1,970	2,030
Total	2,680	2,430
Flame retardants:		
Adhesives	610	217
Plastics	2,290 [r]	1,830
Rubber	42 [r]	42
Textiles	235	206
Other[4]	20	40
Total	3,190 [r]	2,340
Grand total	8,140 [r]	6,770

[r] Revised. W Withheld to avoid disclosing company proprietary data; included in "Other."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes ammunition, cable covering, castings, sheet and pipe, and type metal.

[3] Includes fireworks and rubber products.

[4] Includes paper and pigments.

Note: Secondary antimonial lead production was 3,180 metric tons (t) in 2008 and 3,020 t in 2009.

TABLE 4
INDUSTRY STOCKS OF PRIMARY ANTIMONY IN THE UNITED STATES, DECEMBER 31[1]

(Metric tons of antimony content)

Type of material	2008	2009
Metal	217	154
Oxide	916 [r]	899
Other[2]	357	363
Total	1,490 [r]	1,420

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes ore and concentrate, residues, and sulfide.

TABLE 5
U.S. EXPORTS OF ANTIMONY METAL, ALLOYS, AND WASTE AND SCRAP, BY COUNTRY[1]

	2008		2009	
Country	Gross weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Value (thousands)
Belgium	41	$224	--	--
Canada	6	33	85	$433
China	24	75	5	29
Colombia	20	66	3	20
France	2	7	39	503
Germany	45	166	8	25
India	48	149	17	66
Mexico	74	305	113	362
Netherlands	12	37	13	40
Sweden	41	128	34	104
Switzerland	14	48	3	59
Taiwan	11	35	12	37
United Kingdom	(2)	5	34	215
Venezuela	--	--	15	101
Other	27 r	86 r	3	9
Total	366	1,360	385	2,000

rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 6

U.S. EXPORTS OF ANTIMONY OXIDE, BY COUNTRY[1]

Country	2008 Gross weight (metric tons)	2008 Antimony content[2] (metric tons)	2008 Value (thousands)	2009 Gross weight (metric tons)	2009 Antimony content[2] (metric tons)	2009 Value (thousands)
Australia	11	9	$47	28	23	$105
Belgium	163	135	1,150	17	14	135
Canada	211	175	737	218	181	1,210
Chile	5	4	34	2	2	11
China	87	72	418	44	37	175
Colombia	38	32	220	20	17	96
Costa Rica	13	11	65	2	2	13
France	17	14	61	14	12	61
Germany	185	154	821	49	41	276
Hong Kong	51	42	137	58	48	150
India	23	19	122	63	52	205
Indonesia	17	14	71	54	45	265
Italy	21	17	104	14	12	47
Japan	217	180	919	128	106	596
Korea, Republic of	51	42	162	54	45	203
Mexico	571	474	3,040	993	824	4,950
Netherlands	63	52	222	61	51	282
Singapore	18	15	160	2	2	23
South Africa	14	12	43	52	43	172
Spain	10	8	72	4	3	6
Taiwan	215	178	912	34	28	109
Thailand	70	58	284	16	13	61
United Kingdom	120	100	315	119	99	435
Other	8 [r]	7 [r]	42 [r]	10	8	69
Total	2,200	1,830	10,200	2,060	1,710	9,660

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Antimony content is calculated by the U.S. Geological Survey.

Source: U.S. Census Bureau.

TABLE 7

U.S. IMPORTS FOR CONSUMPTION OF ANTIMONY, BY CLASS AND COUNTRY[1]

Country	2008 Gross weight (metric tons)	2008 Antimony content[2] (metric tons)	2008 Value (thousands)	2009 Gross weight (metric tons)	2009 Antimony content[2] (metric tons)	2009 Value (thousands)
Antimony ore and concentrate:						
Bolivia	129	88	$501	121	83	$521
Canada	2	2	6	(3)	(3)	4
China	154	74	317	62	40	109
Italy	--	--	--	85	43	375
Japan	1	(3)	5	--	--	--
Total	286	164	828	268	167	1,010
Antimony oxide:						
Belgium	1,920	1,590	11,700	1,860	1,540	9,520
Bolivia	97	81	498	1,940	1,610	8,180
China	14,500	12,100	63,300	11,200	9,310	43,100
France	--	--	--	456	378	2,850
Germany	23	19	105	(3)	(3)	7
Hong Kong	20	17	43	--	--	--
India	23	19	122	--	--	--
Japan	169	140	1,470	182	151	1,040
Mexico	9,200	7,640	46,100	2,430	2,020	14,700
Netherlands	4	3	91	154	128	1,080
Taiwan	195	162	824	115	95	557
Vietnam	20	17	51	(3)	(3)	--
Other	5 [r]	4 [r]	59 [r]	(3)	(3)	21
Total	26,200	21,800	124,000	18,300	15,200	81,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Antimony ore and concentrate content reported by the U.S. Census Bureau. Antimony oxide content is calculated by the U.S. Geological Survey.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8

U.S. IMPORTS FOR CONSUMPTION OF ANTIMONY METAL, BY COUNTRY[1]

	2008		2009	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Australia	46	$283	95	$398
Bolivia	120	636	58	236
China	5,190	22,400	3,040	14,900
Hong Kong	384	2,230	--	--
India	--	--	10	82
Mexico	865	1,130	1,170	1,740
Peru	433	2,470	212	995
United Kingdom	1	17	44	362
Vietnam	19	127	119	590
Other	1 [r]	423 [r]	(2)	279
Total	7,050	29,700	4,750	19,600

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9

ANTIMONY: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, antimony content unless otherwise specified)

Country[3]	2005	2006	2007	2008	2009[e]
Australia[e, 4]	120	1,600	1,010	1,500	1,000
Bolivia	5,098	5,460	3,881	3,905 [r]	3,000
Canada[5]	66	226	162	97	56
China[e]	152,000	153,000	163,000	166,000 [r]	140,000
Guatemala	1,007	--	1,000 [e]	-- [r]	-- [6]
Kyrgyzstan[e]	10	50	10	10	10
Peru, refined[e]	807 [6]	691 [r]	590 [r]	531 [r]	530 [p]
Russia, recoverable[e]	3,000	3,500	3,500	3,500	3,500
South Africa[5]	5,979	4,362	3,354	3,370 [r]	2,800
Tajikistan[e]	2,000	2,000	2,000	2,000	2,000
Thailand, content of ore and concentrate	347	1,409	--	--	--
Turkey[e]	1,200	1,100	1,200	1,300	1,700
Total	172,000	173,000 [r]	180,000	182,000 [r]	155,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 18, 2010.

[3] In addition to the countries listed, antimony may have been produced in Iran, but information is inadequate to estimate output.

[4] Antimony content of antimony ore and concentrate, lead concentrates, and lead-zinc concentrates.

[5] Antimony content of concentrate.

[6] Reported figure.

ARSENIC

By William E. Brooks

Domestic tables were prepared by Elsie D. Isaac, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2009, the United States produced no arsenic and relied mostly on Morocco and China, the leading and second ranked import sources, respectively, for arsenic trioxide and on China and Japan, the leading and second ranked import sources, respectively, for arsenic metal. There has been no domestic production of arsenic trioxide or arsenic metal since 1985 following the closure of the ASARCO Inc. copper smelter in Tacoma, WA. Arsenic trioxide has been used mainly for the production of chromated copper arsenate (CCA), a pesticide and preservative used to pressure treat some wood products, and for production of agricultural chemicals. Arsenic metal was used for electronics applications and in nonferrous alloys. The United States remained the world's leading consumer of arsenic trioxide and arsenic metal.

Legislation and Government Programs

In 1975, the Safe Drinking Water Act mandated that the U.S. Environmental Protection Agency (EPA) identify and regulate drinking water contaminants, such as arsenic, that may have adverse effects on human health. The maximum contaminant level for arsenic was established at 0.05 microgram per liter (µg/L), and in 2001, was revised to 0.01 µg/L. At the end of 2009, arsenic removal technology had been tested at sites in California, Minnesota, Nevada, New Hampshire, and Wisconsin. For example, at the Stewart, MN, site, source water contained from 31.4 to 56.4 µg/L arsenic and after treatment, approximately 60% total arsenic was removed. (Williams and others, 2009).

Environmental and Human Health Issues

Arsenic is a naturally occurring element that may be present in drinking water as a result of weathering of arsenic-containing minerals exposed by natural processes or disturbed by mining or other anthropogenic activities; as runoff from arsenic-containing pesticides used in orchards; in wastewater runoff from glass and electronics production; or arsenic released by coal burning. In humans, some of the noncancerous effects of arsenic exposure include blindness, diarrhea, discoloration and thickening of the skin, nausea, stomach pain, and vomiting. Prolonged arsenic exposure has been linked to cancer of the bladder, kidney, lungs, liver, and prostate (Agency for Toxic Substances and Disease Registry, 2007).

As the result of a 4-year bankruptcy case, Asarco LLC, now owned by Grupo Mexico S.A. de C.V. (Mexico, Distrito Federal, Mexico) will make $3.5 billion in payments to settle claims in 16 States that involve liability for pollution at mining and smelting sites once owned by ASARCO. The case was the largest settlement of environmental class in U.S. bankruptcy court history (Metal-Pages, 2009d).

According to university medical research scientists, the ability to have an immune response to H1N1 (Swine Flu) infection was compromised by low levels of arsenic exposure through drinking contaminated well water. Researchers noted that Mexico has areas of very high arsenic in well water that include locations where H1N1 first appeared, and researchers followed up with laboratory experiments on mice. They found that the immune response to exposure to H1N1 in lab animals that had ingested 100 parts per billion (ppb) of arsenic for 5 weeks was weak. Morbidity for arsenic-exposed mice was significantly higher than for lab mice similarly exposed to H1N1. The researchers concluded that arsenic exposure not only disrupts the immune system but also the endocrine system, which results in broad hormonal disruption (Kozul and others, 2009).

In Bangladesh, groundwater was widely used for irrigation of rice paddies; however, the groundwater may contain potentially high concentrations of arsenic. Researchers have found that in seasonally flooded fields, the arsenic concentrations decrease during the monsoon season. They concluded that monsoon floodwater removes from 13% to 62% of the arsenic that is added to the rice paddy from groundwater irrigation and that nonflooded fields were at risk of arsenic accumulation (Roberts and others, 2010).

Nanotechnology may help alleviate water pollution problems by removing contaminants such as arsenic, bacteria, mercury, and pesticides. Researchers at Rice University have used "nanorust" (nanoparticles of iron oxide) to remove arsenic from drinking water. The large surface area of nanorust and the magnetic interaction between the nanoparticles means that 100 times more arsenic can be captured using nanorust than with filtration systems using larger particles. The team is developing nanorust from inexpensive household items, which would reduce production costs and make nanorust a feasible product for widespread use (Science News, 2006).

A chemical-free method to remove arsenic from well water was working in India. The method was developed by European and Indian scientists and tested at Kasimpore, a village in West Bengal State, India, one of the most arsenic-contaminated sites in the world. Wells may have 50 µg/L of arsenic in comparison to World Health Organization guidelines of 10 µg/L. The treatment plants contain a nozzle that sprays oxygen into water pumped from aquifers. The oxygen-rich water oxidizes Fe^{II} that was adsorbed from the groundwater onto the soil into ferric hydroxide, which removes arsenic as a coprecipitation product (Sen Gupta and others, 2009).

Electronic waste (e-waste) may contain arsenic, beryllium, cadmium, copper, gold, lead, mercury, and silver that may be recycled. However, the small-scale recovery of the metals may pose an environmental hazard and risk to human health (Schmit, 2008).

Consumption

Arsenic is one of the components of CCA, a widely used wood preservative used in pressure-treated wood. The major domestic consumers of arsenic, as CCA, include Arch Wood Protection, Inc., Norwalk, CT; Osmose Wood Preserving, Inc., Buffalo, NY; and Viance, a joint venture between Rohm and Haas Co. and Chemical Specialties, Inc., Charlotte, NC. In response to concerns about the effects of arsenic exposure on human health, domestic manufacturers of wood preservatives voluntarily reduced their use of CCA in 2003. The phaseout applied to wood used for boardwalks, decks, fencing, gazebos, picnic tables, and play structures. However, wood treated with CCA prior to December 31, 2003, could still be used, and glue-laminated beams, marine timbers, plywood flooring and roofing, and utility poles could still be treated with CCA (PR Newswire, 2002). In 2004, global arsenic consumption and domestic imports of arsenic declined significantly in response to this voluntary phaseout.

The United States remained the world's leading consumer of arsenic, mainly for the production of CCA. Apparent domestic consumption for arsenic was about 4,740 metric tons (t) in 2009, a 15% increase from about 4,130 t in 2008. The estimated value of arsenic compounds and metal consumed domestically in 2009 was approximately $4.8 million.

In 2009, slightly more than 50% of the arsenic, as arsenic trioxide, was used in the wood preservative industry for nonresidential use. The remainder of the arsenic trioxide was used in agricultural chemicals (either directly or after conversion to arsenic acid) or in glass manufacturing applications. Arsenic acid also was used in glassmaking as a bubble dispersant or decoloring agent. No data were available on the percentages of arsenic used in these traditional use categories.

Some arsenic may be found as an impurity in copper, and alloys containing arsenic have been used to produce hardened copper tools since ancient times. Arsenic metal is used, along with antimony, to harden ammunition, in solders, and in other applications. Grids and posts in lead-acid storage batteries are strengthened by the addition of arsenic metal. Arsenic is one of several metals used as an antifriction additive in babbitt metals (alloys that are used for bearings). Minor amounts of arsenic may be added to lead for use in clip-on wheel weights. However, the EPA has encouraged the reduction of lead, a toxic metal, in wheel weights through a partnership among Federal agencies, States, automobile trade associations, environmentalists, and wheel-weight manufacturers (U.S. Environmental Protection Agency, 2009).

High-purity (99.9999%) arsenic metal is used for gallium-arsenide (GaAs), indium-arsenide (InAs), and indium-gallium-arsenide semiconductors that are widely used in computer, biomedical, communications, and electronics applications. Arsenic may be used for germanium-arsenide-selenide or GaAs specialty optical materials. Arsenic sulfide is one of several substrate materials that are used for optical thin films and interference coatings for applications in data recording media, optical communications systems, and sensors. A mobile telephone typically contains GaAs in its circuitry, of which the arsenic content is less than 1 milligram (International Precious Metals Institute, 2003). Based on reported consumption of gallium, U.S. consumption of arsenic metal in GaAs semiconductors was approximately 20 t in 2009, which was a 50% decrease from a peak of about 40 t in 2000.

Prices

China was the world's leading producer of arsenic trioxide; however, sales were low through May 2009. In May, prices in Beijing, China, for arsenic trioxide (minimum 99%) were $0.39 to $0.41 per kilogram, a decrease from $0.45 per kilogram in February. An official at a Hunan smelter indicated that no arsenic trioxide had been exported since the fourth quarter of 2008 (Metal-Pages, 2009c). In the second quarter, the 99%-pure arsenic trioxide price range in China declined to $0.09 per kilogram, and by mid-September, the price had increased to $0.10 per kilogram because of improved demand from customers (Metal-Pages, 2009a).

In November, prices for arsenic metal increased owing to purchases and a reduction in supplies in China. Prices for 99%-pure arsenic metal increased to $1,247 per metric ton in November from $1,174 per ton in October. A producer indicated that there had been some overseas purchases of arsenic metal and that consumers were expected to replenish their stocks. Prices of $1,300 per ton were quoted; however, overseas buyers bid as low as $1,050 to $1,100 per ton (Metal-Pages, 2009f). By early December, there had been little change in the market, and prices were holding at $1,248 per ton. One producer postponed restarting arsenic metal production, which had been planned for late November (Metal-Pages, 2009b). By the end of December, Chinese domestic suppliers maintained their prices of $1,248 to $1,292 per ton. Export prices of $1,150 to $1,200 per ton were reported (Metal-Pages, 2009e).

Foreign Trade

In 2009, domestic imports of arsenic compounds were 4,660 t contained arsenic, a decrease of approximately 3% compared with the 4,810 t contained arsenic in arsenic compounds imported in 2008. Arsenic trioxide contains 76% arsenic. In 2009, Morocco was the source of 74% of the arsenic trioxide imported into the United States, China was the source of 18%, and Belgium was the source of 8%. Imports of arsenic trioxide from China into the United States in 2009 decreased by 8% to 1,080 t, from 1,180 t in 2008.

In 2009, the United States imported 438 t of arsenic metal, a 16% increase compared with the 376 t of arsenic metal imported in 2008. China was the leading source of arsenic metal in 2009 and provided 370 t of arsenic metal, or 84%; however, this was an increase of 28% compared with the 288 t of arsenic metal that was imported from China in 2008. Arsenic metal was also imported from Japan (15%) and other countries.

Exports of arsenic metal from the United States in 2009 decreased to 354 t from 1,050 t in 2008. Export destinations included Honduras (64%), Colombia (21%), Guatemala (5%), and France (4%). In the Harmonized Tariff Schedule, exported materials are classified only by number and may not be inspected so as to confirm the contents of the shipping container. This may have resulted in misclassification of the exported material, and therefore, exports of material classified as arsenic metal may vary from year to year. This classification may also include arsenic-containing "e-waste," such as computers and other electronics destined for reclamation and recycling (Grossman, 2005; Schmit, 2008), transshipped arsenic metal used for production of small-arms ammunition (Agence France-Presse, 2005; Chicago Tribune, The, 2005), and arsenic alloyed with lead or another metal.

World Review

In 2009, commercial-grade arsenic trioxide was recovered from processing of nonferrous ores or concentrates in 13 countries. Reduction of arsenic trioxide to arsenic metal accounted for all world output of commercial-grade (99%-pure) arsenic metal.

In 2009, China produced approximately 25,000 t of arsenic trioxide and remained the world's leading producer followed by Chile (11,000 t), Morocco (8,500 t), and Peru (4,850 t). Arsenic was also produced in China as a byproduct of gold mining from orpiment (As_2S_3) and realgar (AsS), the more common ore minerals of arsenic (Peters and others, 2002, p. 182). Arsenic trioxide was also produced in Mexico at the San Luis Potosi copper smelter.

Arsenic-containing residues and smelter dusts recovered from nonferrous metals plants in several countries may not have been processed to recover commercial-grade arsenic trioxide in 2009 and may have been stockpiled for future treatment. Production data for most countries were estimated and subject to revision.

Outlook

At yearend 2003, the voluntary decision by the wood preservative industry to eliminate CCA as a wood preservative for certain wood products has led to a decline in U.S. consumption and a decline in arsenic trioxide production in China. The use of alternative wood preservatives and wood alternatives, such as concrete, plastic, or wood composites, will continue to substitute for CCA wood preservatives. Borate-treated wood is resistant to insects and fungal decay, but its use is recommended only for interior or weather-shielded applications. Specific industrial applications, such as marine timber, plywood roofing, and utility poles, are expected to continue to use CCA-treated wood. High-purity arsenic is expected to continue to be used by the electronics industry for GaAs semiconductors. Effects of the global economic decline slowed GaAs industry growth; however, GaAs was expected to continue to represent the principal semiconductor technology, mainly for defense applications, through 2013. Overall, the GaAs market was expected to increase to $4.5 billion by 2013 (Anwar, 2010). World sources of arsenic, as arsenic trioxide and arsenic metal from nonferrous metal processing, are expected to be sufficient to meet projected needs.

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TABLE 1
ARSENIC SUPPLY-DEMAND RELATIONSHIPS[1]

(Metric tons of arsenic content)

	2005	2006	2007	2008	2009
U.S. supply, imports:					
Metal	812	1,070	759	376	438
Compounds	8,330	9,430	7,010	4,810	4,660
Total	9,150	10,500	7,770	5,180	5,100
Distribution of U.S. supply:					
Exports[2]	3,270	3,060	2,490	1,050	354
Apparent demand	5,870	7,450	5,280	4,130	4,740

[1] Data are rounded to no more than three significant digits; may not add to totals shown.
[2] Metal only.

TABLE 2

U.S. IMPORTS FOR CONSUMPTION OF ARSENIC PRODUCTS[1]

Class and country	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)
Arsenic trioxide:				
Belgium	654	$413	514	$297
Bolivia	30	15	--	--
China	1,180	599	1,080	440
Germany	5	17	--	--
Morocco	4,460	1,860	4,530	1,970
Spain	(2)	16	10	36
Total	6,320	2,920	6,130	2,740
Arsenic acid:				
France	89	639	--	--
Germany	(2)	2	--	--
Indonesia	19	22	--	--
Japan	4	11	3	11
Taiwan	3	7	--	--
Total	115	682	3	11
Arsenic sulfide:				
China	--[r]	--[r]	--	--
France	(2)	5[r]	--	--
Italy	(2)	6	77	334
Total	(2)	11	77	334
Arsenic metal:				
China	288	792	370	993
Germany	5	761	1	276
Japan	84	1,050	67	613
United Kingdom	--	--	(2)	5
Total	376	2,610	438	1,890

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3
ARSENIC TRIOXIDE: ESTIMATED WORLD SMELTER PRODUCTION, BY COUNTRY[1, 2, 3]

(Metric tons)

Country[4]	2005	2006	2007	2008	2009
Belgium	1,000	1,000	1,000	1,000	1,000
Bolivia	120 [5]	90 [5]	--	74 [r, 6]	100
Canada	250	250	250	250	250
Chile	11,700	11,700	11,400	10,000	11,000
China	30,000	30,000	25,000	25,000	25,000
Iran	100	100	100	100	100
Japan	40	40	40	40	40
Kazakhstan	1,500	1,500	1,500	1,500	1,500
Mexico	1,664 [5]	1,595 [5]	1,600	513	500
Morocco	8,939 [5]	8,900 [5]	8,950 [5]	8,800	8,500
Peru[7]	3,150 [5]	4,399 [5]	4,321 [r, 5]	4,822 [r, 5]	4,850 [p]
Portugal	15	15	15	15	15
Russia	1,500	1,500	1,500	1,500	1,500
Total	60,000	61,100	55,700	53,600 [r]	54,400

[p]Preliminary. [r]Revised. -- Zero.

[1] Including calculated arsenic trioxide equivalent of output of elemental arsenic compounds other than arsenic trioxide where inclusion of such materials would not duplicate reported arsenic trioxide production.

[2] World totals and estimated data have been rounded to no more than three significant digits; may not add to totals shown.

[3] Table includes data available through March 24, 2010.

[4] Austria, Hungary, the Republic of Korea, Serbia and Montenegro (listed as an individual entity but dissolved their union in June 2006), South Africa, Ukraine, the United Kingdom, and Zimbabwe have produced arsenic and (or) arsenic compounds in previous years, but information is inadequate to make estimates of output levels, if any.

[5] Reported figure.

[6] Estimated exports of arsenic trioxide reported by Bolivia's Ministry of Mines and Metallurgy (2009).

[7] Output of Empresa Minera del Centro del Perú (Centromin Perú) as reported by the Ministerio de Energia y Minas.

ASBESTOS

By Robert L. Virta

Domestic survey tables were prepared by Richard H. Kraft, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

Asbestos has not been mined in the United States since 2002, and imports, mostly from Canada, satisfied the needs of domestic consumers. U.S. apparent consumption declined to 869 metric tons (t) in 2009 from 1,460 t in 2008 because of decreased sales to the roofing products industry. World production was 2.07 million metric tons (Mt) in 2009, a decrease from 2.15 Mt in 2008.

Legislation and Government Programs

Health research and asbestos cleanup continued in Libby, MT, where vermiculite contaminated with asbestos was mined and processed, and at several vermiculite processing plants across the country. The Agency for Toxic Substances and Disease Registry announced plans to invest $8 million in projects to compare the health of people exposed to Libby asbestos in childhood against those not exposed. The study was expected to determine if effects other than lung disease can occur following exposure to Libby asbestos, improve public health records to better track exposure and health outcome, and compare digital-versus-film chest x-rays for efficiency in assessing lung conditions. The U.S. Environmental Protection Agency continued its remedial activities in Libby (Agency for Toxic Substances and Disease Registry, 2009; U.S. Environmental Protection Agency, 2010).

The National Institute of Occupational Safety and Health (NIOSH) released its roadmap for asbestos research in 2008. This plan was reviewed by the National Academy of Sciences and the organization provided recommendations for changes. Some of the recommendations included more focus on the mineralogy of the elongate particles under study, removal of potentially confusing terms from the roadmap glossary section, development of a mineral repository for health research, and further elaboration on its strategy for assessing the health effects of elongate mineral particles (National Academy of Sciences, 2009).

Consumption

U.S. consumption of asbestos was 869 t in 2009, a 41% decrease from 1,460 t in 2008 (table 1). Roofing products accounted for 42% of U.S. consumption; coating and compounds, 30%; diaphragms for the chloralkali industry, 18%; and other, 10%. Most of the asbestos reported under "coating and compounds" probably was used in roofing products. Consequently, roofing applications, which comprised bituminous roof coatings and roof sealants, accounted for 72% of the total U.S. asbestos end-use market (table 2).

Chrysotile was the only type of asbestos used in the United States in 2009, 66% of which was grade 7; the rest consisted of grades 5, 4, and 3, in descending order of percentage.

Prices

The average free alongside ship (f.a.s.) unit value of asbestos fiber exports and reexports was $1,169 per metric ton in 2009, an increase from $938 per ton in 2008 (table 4). The average U.S. customs unit value for all grades of imported asbestos increased to $787 per ton in 2009 from $746 per ton in 2008 (table 5). The average value of imported crude chrysotile, all from Canada, was $200 per ton in 2009, a decrease from $700 per ton in 2008. The average unit value for imports of milled, grade 4 chrysotile was $1,843 per ton in 2009, a decrease from $2,062 per ton in 2008. The unit value of all other grades of asbestos combined was $630 per ton in 2009, an increase from $455 per ton in 2008 (table 5). Unit values of imported chrysotile have fluctuated in recent years because of the small quantities of asbestos being used by industry.

Foreign Trade

The following section summarizes significant trade statistics on asbestos and products manufactured using asbestos. Detailed trade statistics, by country and individual U.S. port districts, are available from the International Trade Commission's Interactive Tariff and Trade Dataweb Web site (U.S. International Trade Commission, undated).

In 2009, U.S. exports of asbestos fiber were 59 t with an f.a.s. value of $69,000, a decrease in tonnage from 368 t valued at $345,000 in 2008. Asbestos has not been produced in the United States since 2002; thus, reported exports probably consisted of reexports of imported fiber or improperly classified products (table 4). The United States exported and reexported $24.5 million of asbestos products in 2009, a decrease from $33.2 million in 2008. Canada was the leading importer, followed by Mexico, the United Kingdom, China, and the Republic of Korea. These five countries accounted for 67% of the value of asbestos products exported and reexported from the United States in 2009 (table 3). The United Kingdom banned the use of asbestos in 1999, so their imports from the United States probably were reexported from the United Kingdom, or they were nonasbestos products misclassified as asbestos products. The same applies to several other countries listed in table 3 that have banned the use of asbestos or asbestos products.

Friction products, including brake linings, clutch linings, and disk pads, accounted for 55% of the value of manufactured products exported in 2009 (table 4). Because no asbestos brake components under Harmonized Tariff Schedule of the United States (HTS) code 6813.20 or asbestos-cement products under HTS code 6811.40 are manufactured in the United States, the values for these two HTS code categories probably represent exports from stocks, reexports of asbestos products, or products incorrectly classified under the HTS codes.

In 2009, the United States imported 869 t of asbestos valued at $684,000. Canada supplied 91% of the tonnage. Asbestos also was imported from Brazil and Zimbabwe (table 5). Only chrysotile was imported into the United States in 2009. Based on the import source, asbestos listed under "other, unspecified asbestos type" in table 5 probably represented chrysotile.

The United States also imported $13.3 million of products with a basis of asbestos and products with a basis of asbestos and magnesium carbonate (U.S. International Trade Commission, undated). Some nonasbestos products probably are included under the asbestos HTS codes based on reported asbestos imports from countries that have banned asbestos use (table 6).

World Review

World production of asbestos was estimated to be 2.07 Mt in 2009, a decrease from 2.15 Mt in 2008. Russia was the leading producer of asbestos, followed by China, Brazil, Kazakhstan, and Canada. These five countries accounted for 99% of the world production (table 7).

Korea, Republic of.—The Republic of Korea enacted the final stage of a ban on the use of asbestos in manufactured products, effective September 2009. Under the ban, asbestos may not be used to manufacture any children's products or products in which asbestos particles may come loose and contact skin. For all other manufactured products, the asbestos content must be less than 0.1%. Under the ban, talc used in the manufacture of paint and wallpaper must be certified to contain less than 1% asbestos (The Chosun Ilbo, 2009).

Zimbabwe.—Workers at the Shabanie Mashaba Mine, a chrysotile mine that is administered by the government, went on strike on August 31, 2009, because of salary issues. The company reportedly also had its electricity disconnected for failure to pay its electric bills. The loss of electrical power resulted in the flooding of the mine (Mpofu, 2010; Whiz, 2010).

Outlook

U.S. consumption continued to decline as markets for asbestos weakened. This trend is likely to continue in the United States as the use of products and technologies that do not require asbestos are further implemented. World production, however, remained nearly 2.0 Mt because of continued demand for asbestos products in many regions of the world. As additional national bans are enacted, world consumption may be further concentrated in fewer regions of the world and world production may begin to decline slightly.

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TABLE 1
SALIENT ASBESTOS STATISTICS[1]

		2005	2006	2007	2008	2009
United States:						
Exports and reexports:[2]						
Unmanufactured, value	thousands	$398	$866	$421	$345	$69
Asbestos products, value[3]	do.	$374,000	$443,000	$29,200	$33,200	$24,500
Imports for consumption, unmanufactured:						
Quantity	metric tons	2,530	2,230	1,730	1,460	869
Value[4]	thousands	$1,420	$1,000	$819	$1,090	$684
Consumption, apparent[5]	metric tons	2,530	2,230	1,730	1,460	869
World, production	do.	2,210,000 r	2,150,000 r	2,240,000 r	2,150,000 r	2,070,000

r Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits.

[2] Free alongside ship value; includes exports of crudes, fibers, stucco, sand, and refuse.

[3] Product export data prior to 2007 also included nonasbestos products.

[4] U.S. customs declared value.

[5] Consumption assumed to equal imports.

TABLE 2
U.S. ASBESTOS CONSUMPTION BY END USE, GRADE, AND TYPE[1, 2]

(Metric tons)

	Chrysotile					
End use	Grade 3	Grade 4	Grade 5	Grade 7	Unspecified grade	Total
2008	4	52	226	932	248	1,460
2009:						
Coatings and compounds[3]	--	--	124	139	--	263
Chlorine industry	2	65	28	--	65	160
Roofing products	--	--	--	365	--	365
Other	--	--	--	72	9	81
Total	2	65	152	576	74	869

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Estimated distribution based upon data provided by the Chrysotile Institute, Montreal, Quebec, Canada.

[3] Most of the asbestos reported under "Coating and compounds" probably was used in roofing products.

TABLE 3
VALUE OF U.S. EXPORTS AND REEXPORTS OF ASBESTOS FIBERS AND ASBESTOS-BASED PRODUCTS[1, 2, 3]

(Thousand dollars)

	2008			2009		
Country	Unmanufactured fiber[4]	Manufactured products	Total	Unmanufactured fiber[4]	Manufactured products	Total
Australia	--	380	380	--	194	194
Brazil	--	837	837	--	165	165
Canada	--	6,630	6,630	--	5,560	5,560
China	52	3,570	3,620	--	1,610	1,610
France	--	53	53	--	218	218
Germany	--	334	334	--	269	269
Italy	--	170	170	--	72	72
Japan	--	529	529	--	477	477
Korea, Republic of	--	2,700	2,700	--	1,520	1,520
Mexico	51	7,290	7,340	--	4,430	4,430
Netherlands	--	34	34	--	9	9
United Kingdom	--	375	375	--	3,240	3,240
Venezuela	--	191	191	--	294	294
Other	242	10,100	10,300	69	6,450	6,520
Total	345	33,200	33,500	69	24,500	24,600

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship value.

[3] Data may include some nonasbestos products based on destination countries that have banned the use of asbestos.

[4] Includes exports of crudes, fibers, stucco, sand, and refuse. May also include nonasbestos materials.

Source: U.S. Census Bureau.

TABLE 4
U.S. EXPORTS AND REEXPORTS OF ASBESTOS AND ASBESTOS-BASED PRODUCTS[1]

	2008		2009	
	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Unmanufactured, asbestos[3]	368	$345	59	$69
Manufactured:				
Cement products[4]	NA	457	NA	427
Friction products[5]	NA	16,000	NA	13,500
Gaskets, packing and seals	NA	1,730	NA	1,270
Paper and millboard	NA	1,560	NA	317
Other articles[6]	NA	13,400	NA	9,040
Total	NA	33,200	NA	24,500

NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship value.

[3] Includes crudes, fibers, stucco, sand, and refuse. May also include nonasbestos materials.

[4] May include reexports and also cellulose fiber panel, sheet, tile, and tube cement products because asbestos-cement products are not manufactured in the United States.

[5] May include some nonasbestos brake and clutch shipments.

[6] May also include some nonasbestos materials.

Source: U.S. Census Bureau.

TABLE 5

U.S. IMPORTS FOR CONSUMPTION OF ASBESTOS FIBERS, BY TYPE AND ORIGIN[1]

Type	Canada		Brazil		Other[2]		Total	
	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)
2008:								
Chrysotile:								
Crude	30	$21	--	--	--	--	30	$21
Milled, grade 4	40	43	--	--	220	$492	260	536
All other	821	252	--	--	28	69	849	321
Other, unspecified asbestos type	324	213	--	--	--	--	324	213
Total	1,220	529	--	--	248	561	1,460	1,090
2009:								
Chrysotile:								
Crude	40	8	--	--	--	--	40	8
Milled, grade 4	106	178	7	$19	14	38	127	234
All other	332	128	53	147	--	--	385	275
Other, unspecified asbestos type	317	167	--	--	--	--	317	167
Total	795	480	60	166	14	38	869	684

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes South Africa and Zimbabwe in 2008 and Zimbabwe in 2009.

[3] U.S. customs declared value.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS OF PRODUCTS WITH BASIS OF ASBESTOS IN 2009

HTS[1] code	Category	Quantity (metric tons)	Value[2]	Major sources[3]	Percentage of category total[4]
2524.00.00.00	Asbestos	389	$684,000	Canada	91% of weight.
6811.40.00.00	Asbestos-cement products	10,600	3,370,000	Mexico, Canada	100% of weight.
6812.80.90.00	Other, fabricated crocidolite fibers; clothing[5]	(6)	2,840	Germany[7]	Do.
6812.91.10.00	Footwear, fabricated asbestos fibers; clothing[8]	1	14,000	Pakistan	Do.
6812.91.90.00	Other, fabricated asbestos fibers; clothing[8]	(6)	13,500	Taiwan, China	Do.
6812.92.00.00	Felt, millboard, and paper[8]	NA	212,000	China, South Korea	100% of value.
6812.93.00.00	Compressed asbestos fiber jointing[8]	NA	476,000	Mexico, India	98% of value.
6812.99.00.01	Other, miscellaneous[8]	33	208,000	Mexico	100% of weight.
6812.99.00.02	Yarn and thread[8]	1	43,000	China	Do.
6812.99.00.03	Cord and string[8]	(6)	6,230	Japan[7]	Do.
6812.99.00.04	Woven or knitted fabric[8]	5	34,000	China, Mexico	Do.
6812.99.00.20	Gaskets, packing, and seals[8]	246	1,710,000	China	94% of weight.
6812.99.00.25	Building materials	NA	22,400	France[7]	100% of weight.
6812.99.00.55	Other, fabricated asbestos fiber[8]	NA	248,000	South Africa	96% of value.
6813.20.00.10	Brake lining and pads, civil aircraft[8]	NA	1,740,000	France[7]	96% of value.
6813.20.00.15	Brake lining and pads, other	NA	4,110,000	China, Japan[7]	57% of value.
6813.20.00.20	Articles for use in civil aircraft	NA	15,600	United Kingdom[7]	100% of value.
6813.20.00.25	Other, friction materials	NA	401,000	Peru, Bolivia, Japan[7]	79% of value.

Do. Ditto. NA Not available.

[1] Harmonized Tariff Schedule of the United States.

[2] U.S. Customs declared value.

[3] Countries are listed in decreasing order.

[4] Percentage contribution of total imports by major import sources, by weight or value.

[5] Products likely to have been inaccurately classified and products probably do not contain crocidolite.

[6] Less than ½ unit.

[7] Source likely a supplier of nonasbestos products only.

[8] Mixtures with basis of asbestos or with a basis of asbestos and magnesium carbonate.

Source: U.S. Census Bureau.

TABLE 7
ASBESTOS: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Argentina	260	299	282	298 [r]	290
Brazil, fiber	236,047	227,304	254,204	287,673 [r]	288,000 [p]
Bulgaria[e]	-- [r]	-- [r]	-- [r]	--	--
Canada[e]	200,000	200,000	180,000 [4]	160,000 [r]	150,000
China[e]	400,000	360,000	390,000	380,000 [r]	380,000
Colombia, crude ore[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
India[e]	19,000	20,000	21,000	20,000	19,000
Iran[e]	1,300	1,300	-- [r]	-- [r]	--
Kazakhstan	305,500 [r]	314,700	292,600	230,100	230,000
Russia[e]	925,000	925,000	1,025,000 [4]	1,017,000 [4]	1,000,000
Serbia	4,080 [5]	4,500	-- [r]	--	--
Zimbabwe[e]	122,041 [4]	100,000	80,000	50,000	--
Total	2,210,000 [r]	2,150,000 [r]	2,240,000 [r]	2,150,000 [r]	2,070,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Marketable fiber production. Table includes data available through March 30, 2010.

[3] In addition to the countries listed, Afghanistan, North Korea, Romania, and Slovakia also produce asbestos, but output is not officially reported, and available general information is inadequate for the formulation of reliable estimates of output levels.

[4] Reported figure.

[5] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

BARITE

By M. Michael Miller

Domestic survey data and tables were prepared by Raymond I. Eldridge III, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2009, primary barite production (sold or used by producers) totaled 383,000 metric tons (t) valued at $19.9 million, and apparent consumption was 1.77 million metric tons (Mt). Imports were 1.43 Mt and exports were 49,000 t.

Barite is the mineralogical name for barium sulfate. In commerce, the mineral is sometimes referred to as barytes. In this report, the term primary barite refers to the first marketable product, which includes crude barite that usually has undergone simple beneficiation methods, such as jigging, tabling, washing, or more complex methods, such as flotation, heavy-media separation, and magnetic separation. Most crude barite requires some upgrading to minimum purity or density levels.

Production

Domestic production and sales data for barite were derived from voluntary responses to the U.S. Geological Survey (USGS) canvass of 7 mines and 25 grinding plants. The USGS received full or partial responses from 6 mines and 21 grinding mills, representing 80% of the quantity of ground barite sold. Most of the nonrespondents were grinding mills. Estimates were made using prior year data and other industry data. Seven mines were included in the survey—five were producing and two were idle.

Of the canvassed producing mines, four were in Nevada, and one was in Georgia; the idle mines were in Nevada. There were 25 grinding plants operating at the end of the reporting year. The Georgia mine and three of the Nevada mines had associated nearby grinding plants, while the fourth Nevada mine shipped its ore to its grinding plant in Wyoming. Most Nevada barite ore was ground at nearby company-owned grinding mills, but ore also was shipped to grinding mills in Canada and Wyoming. Some ore was shipped to plants on the U.S. Gulf Coast for grinding. This has been an uncommon practice in recent years because the cost of transport made Nevada barite uncompetitive with imported barite. Although import prices for barite from China have increased substantially in the past few years, shipments of barite to the Gulf Coast remain rare. Demand in the Western United States and Western Canada was so strong in recent years that Nevada barite producers were able to sell all their production to western customers.

Crude barite production was 383,000 t in 2009, a decrease of 41% compared with that of 2008. The value of domestic production was $19.9 million, a decrease of 36%. The bulk of mine production was from Nevada, with a small amount from Georgia. The large decrease in Nevada's mine production was caused by the sharp downturn in gas exploration when natural gas prices dropped as a result of the recession and economic downturn.

In 2009, there were four active barite mines in Nevada—Big Ledge Mine (NOV Minerals LP, formerly Spirit Minerals LP) and Rossi Mine (Halliburton Energy Services-Baroid) in Elko County, and Argenta Mine (Baker Hughes Drilling Fluids) and Greystone Mine (M-I L.L.C. operating as M-I SWACO) in Lander County. In addition to these Nevada operations, there was one small barite producer in Georgia—New Riverside Ochre Co., Inc.

Canada's Bravo Ventures Group Inc. (Vancouver, British Columbia) announced that it had signed an option agreement with Baker Hughes (Houston, TX) whereby Baker Hughes could acquire 100% of any barite ore at Bravo's Shoshone Pediment gold project in the Battle Mountain-Eureka gold trend in central Nevada. Bravo's plans involved targeting two potential gold occurrences, both located below the barite beds. The Bravo property is adjacent to properties Baker Hughes plans to mine for barite, so this agreement potentially would provide additional barite ore to supplement production from its own mining operations (Bravo Ventures Group, Inc., 2009).

Kent Exploration Inc. (Vancouver, British Columbia, Canada) announced that it received mine plan approval from the U.S. Bureau of Land Management for the company's Flagstaff, WA, barite property. The approved mine plan allows the mining of a maximum of about 91,000 metric tons per year (t/yr) (100,000 short tons per year) of barite from the historic open pit mine on the property. CE Minerals produced about 77,000 t (85,000 short tons) of barite from the site in the early 1980s and reported a remaining resource of approximately 1.1 Mt (1.2 million short tons) grading 4.2 specific gravity. During the first year of operation, Kent Exploration planned to test the economics of the project by crushing, separating, and upgrading to 4.1 specific gravity the estimated 27,000 t (30,000 short tons) of existing stockpiled barite ore. The company had already signed a supply agreement with a customer for 18,000 t/yr (20,000 short tons per year) (Kent Exploration Inc., 2009).

In 2009, the leading companies that mined and ground barite in the United States were also major oil service companies, which included Baker Hughes Drilling Fluids (a division of Baker Hughes Inc.), Baroid Fluid Services (the drilling fluids and industrial barite subsidiary of Halliburton Energy Services, Inc.), and M-I SWACO (a joint venture between Smith International Inc. and Schlumberger Ltd.). Baker Hughes, Halliburton, and M-I SWACO operated in many countries, mining barite and providing drilling sales and services. These three companies operated barite mines with associated beneficiation mills and grinding plants in Nevada and also operated grinding plants in Louisiana and Texas.

The fourth active barite producer in Nevada was Spirit Minerals LP (Wells, NV), which was acquired by National Oilwell Varco Inc. (Houston, TX) in May 2009 and renamed NOV Minerals LP (National Oilwell Varco Inc., 2010a, p. 9). NOV Minerals operated a grinding plant in Evanston, WY, which ground crude barite from its Dry Creek jig mill and crude barite stockpiled from mining operations in the 1980s.

In 2009, there were 14 grinding operations on the coast of the Gulf of Mexico (6 in Louisiana and 8 in Texas) that produced barite to American Petroleum Institute (API) specifications. These stand-alone grinding plants primarily processed crude barite imported from China and India that was ground to API specifications for the oil and gas drilling market. Baker Hughes had single plants in Morgan City, LA, and Corpus Christi, TX. M-I SWACO (M-I LLC) operated single mills in Amelia, LA, and Galveston, TX. Baroid (Halliburton) had two plants in Louisiana at Lake Charles and New Orleans, and a single plant in Corpus Christi, TX. In late 2009, Halliburton started construction of a new grinding mill in Larose, LA. Larose is in Lafourche Parish, and the new plant location was designed to allow for easy transport of barite to Halliburton's wharf facilities at Port Fourchon that support offshore oil drilling operations in the Gulf of Mexico (Schmidt, 2009).

In addition to the barite mining companies, there were a number of other companies that operated grinding mills primarily designed to process imported crude barite. These included Excalibar Minerals Inc. (a division of Newpark Resources, Inc. of Houston), a major barite importer and grinder with one mill in New Iberia, LA, and two mills in Texas at Corpus Christi and Houston. These mills primarily supplied the oil and gas drilling market. The company also operated a grinding plant in Tennessee mostly serving nondrilling markets. There were other, smaller companies near the Gulf of Mexico that received imported barite by ship through ports in Louisiana and Texas. These included Milwhite, Inc. and U.S. Clay LP (each with a single plant in Brownsville, TX) and Ambar Drilling Fluids LP in Houma, LA. At yearend, National Oilwell Varco was negotiating to acquire Ambar; the deal was expected to be finalized in early 2010 (National Oilwell Varco Inc., 2010b).

Grinding plants that produced commercial filler-grade barite or chemical-grade barite were located primarily in the Southeast, Midwest, and Texas. Only four companies reported sales of barite for nondrilling uses, and by far the leading producer was CIMBAR Performance Minerals, Inc. (Cartersville, GA), which operated two grinding mills in Georgia, one in Missouri, and one in Texas. In October, CIMBAR expanded into the Midwest and added to its product line by acquiring Barretts Minerals Inc.'s multi-mineral processing plant in Mt. Vernon, IN. The plant will produce barite in addition to calcium carbonate and talc (CIMBAR Performance Minerals, Inc., 2009a). In addition, CIMBAR expanded annual milling capacity at its Houston, TX, plant by about 362,000 t (400,000 short tons) to expand the company's presence in the drilling market (CIMBAR Performance Minerals, Inc., 2009b).

Consumption

In 2009, apparent consumption of barite decreased by 45% to 1.77 Mt compared with that in 2008 (table 1). Ground barite sales decreased by 27% to 2.08 Mt in 2009 from 2.84 Mt in 2008. In 2009, sales by grinding plants in Louisiana decreased by 28% to 921,000 t. Grinding plant sales in Texas decreased by 31% to 569,000 t, while sales by plants in all other States decreased by 20% to 591,000 t (table 2). About 1.96 Mt, or 94%, of barite sales from domestic crushers and grinders was for petroleum well-drilling markets, and the remaining 6% was for industrial end uses (table 3).

The leading application for barite is as a weighting agent in natural gas and oil field drilling muds to suppress high formation pressures and prevent blowouts. As a well is drilled, the bit passes through various formations, each with different characteristics. The deeper the hole, the more barite is needed as a percentage of the total mud mix. An additional benefit of barite is that it does not interfere with magnetic measurements taken in the borehole, either during logging-while-drilling or in separate drill hole logging.

Barite used for drilling petroleum wells can be black, blue, brown, buff, or gray depending on the ore body. Most barite needs to be ground to a small uniform size before it is used as a weighting agent in petroleum well-drilling mud based on specifications set by the API or the former Oil Companies' Materials Association.

The barite is finely ground so that at least 97% of the material, by weight, can pass through a 200-mesh (Tyler) [75-micrometer (μm)] screen, and no more than 30%, by weight, can be less than 6 μm, effective diameter, which is measured using sedimentation techniques. The ground barite also must be dense enough so that its specific gravity is 4.2 or greater, soft enough to not damage the bearings of a tricone drill bit, chemically inert, and containing no more than 250 milligrams per kilogram of soluble alkaline salts (American Petroleum Institute, 1993, p. 6–11). A small percentage of iron oxide is allowable. Although the current API standard for barite calls for a specific gravity of 4.2, in 2008 the API began examining a proposal to lower the barite specific gravity specification to 4.1. A final vote on the proposal was expected in 2009, and it was anticipated that a revised API Specification 13A, Specification for Drilling Fluids Materials, would be issued in 2010 (Moores and O'Driscoll, 2009). The API standard does not address heavy-metal impurities, but barite derived from base-metal deposits may contain heavy metals such as cadmium and mercury and discharges of these may be regulated under environmental law. For example, U.S. environmental regulations pertaining to offshore drilling allow drilling waste discharges containing barite only if the barite contains less than 3 parts per million cadmium and 1 part per million mercury (Drilling Waste Management Information System, undated).

With the contraction of the U.S. economy in 2009, energy demand was significantly reduced and this resulted in lower oil and gas prices compared with their peaks in the summer of 2008. Reduced energy demand and lower energy prices were reflected in 2009 by the large decrease in domestic oil and gas drilling. Natural gas prices (wellhead), which had peaked in June 2008 at $10.82 per thousand cubic feet, continued to slide in 2009, dropping to a low of $2.92 per thousand cubic feet in September before recovering somewhat to $4.44 per thousand cubic feet in December. Oil prices (U.S. spot price) nearly doubled from their low point of less than $32 per barrel in January 2009 to nearly $70 per barrel in December 2009, but this was still 40% below its peak of $134 per barrel in June 2008 (U.S. Department of Energy, Energy Information Administration, 2010a, b).

The sharp decrease in oil and gas prices discouraged exploration. The weekly U.S. drill rig count in 2009 hit a low of 876 in late summer before recovering to 1,189 at yearend. This was still significantly lower than the 2008 yearend count of 1,721. The average monthly drill rig count for 2009 was 1,086 or nearly 800 operating rigs less than that of 2008. Much of the rig count decrease was in gas exploration, which was reflected by the percentage of drill rigs exploring for natural gas decreasing to 65% from about 80% in 2008 (Baker Hughes Inc., 2010). These factors caused the sharp decrease in barite consumption in 2009 compared with that of 2008.

In 2009, sales of domestic and imported barite sold for industrial uses decreased by 10% to 118,000 t (table 3). Industrial end uses such as barium chemicals (the largest by volume is barium carbonate), filler in paint and plastics, and powder coatings all require the barite to be ground to a small uniform size. The size depends on the use, but for paint- and plastic-grade material, it averages about 2 to 3 µm. Barite-containing materials that are used for sound reduction in engine compartments are gaining market share among automotive manufacturers. Barite also is used in the base coat of automobile finishes for smoothness and corrosion resistance and continues to be used in friction products for automobiles and trucks.

Barite that is used as an aggregate in "heavy" cement or radiation-shielding cement is crushed and screened to sizes ranging from 4.75 millimeters (0.187 inches) to 3.75 centimeters (1.5 inches) for the coarse grade. New Riverside Ochre (Cartersville, GA) is the leading supplier of barite aggregate.

Foreign Trade

Barite exports in 2009 were 49,300 t, a 20% decrease compared with those of 2008. Most exports went to Canada (77%) in the form of crude barite, which was ground in Canada and then consumed for oil and gas drilling in the western provinces of Alberta, British Columbia, and Saskatchewan. The bulk of the remaining exports went to Brazil (10%) and Mexico (9%) (table 4).

Assignment of the correct harmonized tariff schedule (HTS) number by importers is sometimes problematic. As a result, in prior years, adjustments were made in an attempt to classify imports of crude natural barite, ground barite, and other sulfates of barium by type and use. These adjustments involved separating, by unit value, imports intended for use in drilling muds (crude and ground barite), and all other uses (other sulfates of barium). Beginning in 2008 this practice was discontinued, and the data shown in table 5 for 2008 and 2009 are as reported by the U.S. Census Bureau.

Combined imports of barite decreased by 45% compared with those of 2008. Imports totaled only 1.42 Mt, which was the lowest annual import total in a decade. China continued to be the primary source accounting for 93% of the total crude and ground material. Imports for the several forms of barite reported under the HTS nomenclature "Other sulfates of barium" were 10,600 t, or a decrease of about 24% compared with those of 2008 (table 5).

There is a tariff on U.S. imports of crude barite equal to $1.25 per metric ton, but there is no tariff on imports of ground barite. As a result, some of the major importers of crude barite have applied for and received foreign trade zone (FTZ) status for their grinding mills in the United States. In 2007, M-I SWACO received FTZ approvals for the company's grinding plants in Amelia, LA, and Galveston, TX. In 2008, Baker Hughes received FTZ approvals for its grinding plants in Morgan City, LA, and Corpus Christi, TX. In addition, in December, Halliburton received FTZ approvals for its grinding plants in Westlake, LA, and Corpus Christi, TX. In 2009, Excalibar Minerals submitted an application for FTZ status for its Corpus Christi, TX, grinding mill, but had not received approval by yearend. FTZ status means that the ground barite produced by these mills will be reported as imports for consumption and not crude barite received from foreign suppliers (U.S. Department of Commerce, Import Administration, 2010).

Transportation

In recent years, more than 80% of U.S. barite consumption has been supplied by imports (primarily from China). Most barite imports are shipped in handymax-size bulk carriers (typically 35,000- to 60,000-t deadweight tonnage). After being ground to API specifications, barite is transferred directly to containers on barges docked in canals, lakes, and rivers near the grinding mills for bulk delivery to offshore drilling platforms. These near-shore barite staging locations also are convenient to the clusters of onshore areas with significant petroleum production in the Petroleum Administration for Defense (PAD) District 3. The PAD districts were World War II divisions of the oil-producing areas of the United States; these designations continue to be used.

Prices

The average sales value for primary barite from mines and their associated beneficiation plants in the United States increased to $51.90 per metric ton, an increase of 9% compared with that of 2008 (table 1). The average sales values for drilling-grade barite ground in Louisiana and Texas increased significantly, although these large increases may not reflect the true change in values. After analyzing the 2008 data, it is thought that some of the 2008 reported value data and estimates were too low. Compared with those of 2008, the average sales value for drilling-grade barite ground in Louisiana increased to about $145 per ton, while the sales value for drilling-grade barite ground in Texas increased to about $162 per ton. The average value for all grades ground in Texas increased to $170 per ton, while the sales value of barite ground in other States increased to $130 per ton (table 2). Barite for barium chemicals, filler and extender, and glass increased by 12% to $346 per ton for 2009 compared with that of 2008 (table 3).

December U.S. published import prices for barite from China, API grade, lump, including cost, insurance, and freight, U.S. Gulf Coast, were in a range of $94 to $108 per ton or essentially unchanged from those of 2008. The price for Indian barite, however, decreased significantly; December 2009 import prices were listed in the range of $97 to $99 per ton compared with a range of $106 to $130 per ton in December 2008. The price of chemical-grade barite from China decreased from $140 per ton in December 2008 to a range of $92 to $114 per ton in December 2009 (Industrial Minerals, 2009).

World Review

Ireland.—Sunrise Diamonds Plc (Macclesfield, United Kingdom) announced that it had been granted a prospecting license for barite, base metals, gold, platinum, and silver at a former barite mine near Bantry in County Cork. The mine was worked from 1864 to 1922 and supplied barite to the local Irish paint industry. Drilling performed in the 1980s suggested that the barite ore was more extensive than previously thought. The company was targeting the Derryginagh barite deposit for possible production of high-value white barite, which is used as a filler in paints and plastics (Crain's Manchester Business, 2009).

Outlook

Long-term U.S. demand for oil and gas is expected to continue to drive domestic exploration. The global recession of 2008–09 resulted in dramatic decreases in energy consumption and associated fuel prices. The United States economic recovery has been slow and energy consumption and fuel prices have remained low as a result. At yearend 2009, about 65% of domestic drilling was for natural gas, and future demand for barite in the United States will likely depend mainly on rising natural gas consumption and higher natural gas prices. Energy consumption is expected to increase as the economy improves and business output increases, which is expected to provide upward pressure on demand and prices. The U.S. economy is expected to increase at a modest rate through 2011, and natural gas prices are expected to edge upward in response. The monthly number of operating drill rigs was steadily increasing from its low point in the summer of 2009, which indicated increasing demand for barite.

In the future, natural gas' share of U.S. power generation is likely to increase because of relatively low natural gas prices and the prospect of stricter environmental controls on powerplant emissions. These conditions may result in power companies deferring coal-fired powerplants and building cleaner gas-fired plants in their place. Increased natural gas use may be bolstered by recent increases in the Nation's estimated gas reserves, which have surged by 35% since 2006, according to a study released in June 2009 by the Potential Gas Committee (PGC). The PGC consists of volunteer members from the natural gas industry, government, and academic institutions, who biennially assess the size and location of the nation's natural gas resource base. Much of this increase in gas reserves is the result of new and advanced exploration, well drilling, and well completion technologies, which allows recovery of natural gas from active and newly developing shale-gas fields (Potential Gas Committee, 2009). A switch from coal to natural gas in new powerplants would likely provide a boost to domestic drilling and increase the demand for barite.

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TABLE 1
SALIENT BARITE STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2005	2006	2007	2008	2009
United States:					
Barite, primary:					
Sold or used by producers:					
Quantity	489	589	455	648	383
Value	17,600	23,500	20,600	30,900	19,900
Exports:					
Quantity	93	72	15	62	49
Value	9,930	12,100	6,300	10,500	10,200
Imports for consumption:[2]					
Quantity	2,690	2,550	2,600	2,620	1,430
Value	162,000	160,000	193,000	208,000	129,000
Consumption, apparent[3]	3,080	3,070	3,040	3,210	1,770
Crushed and ground, sold or used by processors:[4]					
Quantity	2,720	3,040	2,980	2,840	2,080
Value	238,000	289,000	308,000	317,000	307,000
World, production	7,870 [r]	7,960 [r]	7,730 [r]	8,200 [r]	6,130 [e]

[e] Estimated. [r] Revised

[1] Data are rounded to no more than three significant digits.

[2] Includes crude, ground, and other barite imports.

[3] Sold or used plus imports minus exports.

[4] Includes imports.

TABLE 2
CRUSHED AND GROUND BARITE SOLD OR USED BY PROCESSORS IN THE UNITED STATES, BY STATE[1, 2]

	2008			2009		
State	Number of plants	Quantity (thousand metric tons)	Value (thousands)	Number of plants	Quantity (thousand metric tons)	Value (thousands)
Louisiana	6	1,280	$129,000	6	921	$134,000
Texas	7	822	104,000	8	569	96,000
Other[3]	11	742	84,900	12	591	77,100
Total	24	2,840	317,000	26	2,080	307,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes imports.

[3] Includes Georgia, Illinois, Missouri, Nevada, Tennessee, and Wyoming.

TABLE 3
CRUSHED AND GROUND BARITE SOLD OR USED BY PROCESSORS IN THE UNITED STATES, BY USE[1, 2]

(Thousand metric tons and thousand dollars)

	2008		2009	
Use	Quantity	Value	Quantity	Value
Barium chemicals, filler and (or) extender, glass	131	40,400	118	40,800
Well drilling	2,710	277,000	1,960	266,000
Total	2,840	317,000	2,080	307,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes imports.

TABLE 4
U.S. EXPORTS OF NATURAL BARIUM SULFATE (BARITE), BY COUNTRY[1]

	2008		2009	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Brazil	31	$27	4,930	$1,270
Canada	54,800	8,240	37,700	7,020
India	248	68	--	--
Japan	604	136	--	--
Mexico	2,750	1,010	4,310	1,200
Mozambique	--	--	812	201
Oman	250	99	858	152
Trinidad and Tobago	2,600	714	92	38
Venezuela	--	--	202	64
Other[2, 3]	294 r	226 r	341	214
Total	61,600	10,500	49,300	10,200

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes countries with full year quantities of less than 200 metric tons.

[3] Includes China, Costa Rica (2009), Ecuador, Israel (2008), Italy (2009), Republic of Korea (2008), Lebanon (2009), Malaysia, New Zealand (2009), Russia (2008), Taiwan (2009), and Thailand.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF BARITE, BY COUNTRY[1]

	2008		2009	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Crude:				
Canada	--	--	621	$17
China	1,860,000	$151,000	502,000	54,000
India	48,500	7,180	41,800	3,540
Japan	1	6	6	13
Mexico	10,400	867	5,590	465
Morocco	3,870	307	21,800	1,930
Netherlands	1	2	--	--
Total	1,920,000	160,000	572,000	60,000
Ground:				
Canada	672	191	--	--
China	656,000	32,300	826,000	55,400
Germany	787	650	569	548
India	--	--	23,800	1,790
Japan	--	--	88	225
Mexico	3,310	540	764	129
Morocco	4,530	295	--	--
Switzerland	22,200	1,030	--	--
United Kingdom	21	13	--	--
Total	688,000	35,000	851,000	58,100
Other sulfates of barium:				
Brazil	--	--	78	39
Canada	--	--	1	2
China	4,650	2,900	3,550	2,230
Germany	5,940	6,430	4,870	6,020
Italy	2,220	1,790	1,540	1,340
Japan	726	1,610	527	1,220
Mexico	20	14	--	--
Spain	302	200	14	12
Switzerland	--	--	2	4
United Kingdom	--	--	(3)	3
Total	13,900	12,900	10,600	10,900

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight value.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF BARIUM CHEMICALS[1]

	2008		2009	
	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Chloride	255	$310	466	$551
Oxide, hydroxide, peroxide	6,360	9,860	2,890	5,050
Carbonate, precipitated	3,340	2,410	814	649

[1] Data are rounded to no more than three significant digits.

[2] Cost, insurance, and freight value.

Source: U.S. Census Bureau.

TABLE 7
BARITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2005	2006	2007	2008	2009[e]
Algeria	52,813	64,787	63,098	60,088	60,000
Argentina	3,355	6,276	37,979	3,170 [r]	4,000
Australia[e]	20,000	21,000	16,000	16,000	16,000
Bolivia	11,379	8,943	8,245	10,900 [r]	1,780
Brazil, beneficiated	39,545	19,151	13,311	7,321 [r]	7,500 [p]
Bulgaria[e, 3]	76,600	74,500	51,000	40,000	14,300
Burma	2,058	2,930	6,813	5,679	7,623
Canada	23,000	20,000	9,000	12,000	15,000
China[e]	4,200,000	4,400,000	4,400,000	4,600,000	3,000,000
France[e]	82,000	30,000	--	--	--
Germany	88,591	85,524	88,265	78,941 [r]	75,000
India[e]	1,200,000	950,000	1,000,000	1,100,000	1,200,000
Iran[e, 4]	231,184 [5]	246,000	249,495 [r, 5]	296,000 [r]	200,000
Italy[e]	4,722 [5]	5,000	5,000	5,000	3,500
Kazakhstan[e, 6]	95,000 [5]	95,000	95,000	95,000	95,000
Laos[e]	28,500 [5]	29,000	29,000	29,000	29,000
Mexico	268,657	206,106	185,921	140,066	151,791
Morocco[3]	335,000	506,000 [e]	492,000 [r]	573,000 [r]	430,000
Nigeria[e, 7]	6,000	6,300	5,000	5,000	5,000
Pakistan	42,087	45,169	44,000	43,000	42,000
Peru	17,300	23,800	27,369	42,660	27,875
Russia[e]	63,000	63,000	63,000	63,000	63,000
Slovakia, concentrate	13,000	16,000	11,000	12,950	13,000
Spain	38,000 [r]	45,000 [r]	35,000 [r]	--	--
Thailand	101,186 [r]	96,469 [r]	8,631 [r]	9,180 [r]	9,000
Turkey	157,179	161,993 [r]	184,041 [r]	170,000 [r, e]	150,000
United Kingdom[e]	62,000	50,000	55,000	50,000	50,000
United States[8]	489,000	589,000	455,000	648,000	383,000
Vietnam[e]	116,000	90,000	90,000	80,000	70,000
Other[9]	4,789	4,708	1,664	2,958	2,950
Total	7,870,000 [r]	7,960,000 [r]	7,730,000 [r]	8,200,000	6,130,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 24, 2010.

[3] Estimated marketable production based on export data.

[4] Data are for fiscal year beginning March 21 of that stated.

[5] Reported figure.

[6] Estimated marketable barite, however, reported figures are as follows, in metric tons: 2005–06—251,000; and 2007–09—not available.

[7] Considerably more barite is produced, but it is considered to be commercially unusable.

[8] Crude barite sold or used by producers.

[9] Includes Afghanistan, Bosnia and Herzegovina, Chile, Colombia, Egypt, Guatemala, and Poland.

BAUXITE AND ALUMINA

By E. Lee Bray

Domestic survey data and tables were prepared by Danielle L. Militello, statistical assistant, and the world production tables were prepared by Lisa D. Miller, international data coordinator.

In 2009, almost all the 6.62 million metric tons (Mt) of bauxite consumed in the United States was imported. U.S. production and shipments of alumina (calcined equivalent) were 3.06 Mt. An estimated 87% of domestic shipments was used for metal production. World production of bauxite totaled 199 Mt; the leading producing countries, in descending order of production, were Australia, China, and Brazil. World production of alumina was estimated to be 76.4 Mt; China, Australia, and Brazil were the leading producing countries.

Production

Bauxite.—For many years, domestic mines have supplied less than 1% of the U.S. requirement for bauxite, all of which was used in nonmetallurgical products, such as abrasives, chemicals, proppants, and refractories. Thus, the United States imported almost all the bauxite that it required.

Alumina.—U.S. production of alumina, which was derived exclusively from imported metallurgical-grade bauxite, was 28% lower in 2009 than in 2008 (table 2). During the first quarter of the year, Gramercy Alumina LLC cut the production rate at its 1.25-million-metric-ton-per-year (Mt/yr) alumina refinery in Gramercy, LA, to 500,000 metric tons per year (t/yr) from 1 Mt/yr. However, as prices recovered, Gramercy increased production in September, and by yearend had returned to full production (Noranda Aluminum Holding Corp., 2009a, b). Citing low alumina and aluminum prices, Sherwin Alumina Co. cut production at the end of March at its 1.6-Mt/yr refinery in Corpus Christi, TX, to 960,000 t/yr (Sherwin Alumina Co., 2009).

Consumption

Bauxite.—Domestic production and consumption data for bauxite and alumina were obtained by the U.S. Geological Survey from three voluntary surveys. The "Bauxite Consumption" survey was sent to 31 operations, 24 of which responded, representing approximately 89% of the bauxite consumed for uses other than cement listed in table 4.

Total domestic consumption of bauxite declined by 31% compared with that of 2008 as a result of cutbacks at alumina refineries late in 2008 and in the first quarter of 2009. In 2009, 98% of the bauxite consumed in the United States was refined to alumina [an estimated 2.11 metric tons (t) of dried bauxite was required to produce 1 t of alumina]; the remaining 2% was consumed in nonmetallurgical applications (table 4).

Alumina.—An estimated 87% of the net alumina imports and alumina shipped by U.S. alumina refineries went to primary aluminum smelters for metal production. In 2009, 14 domestic primary aluminum smelters consumed 3.45 Mt of alumina, a decrease of 35% compared with the amount of alumina consumed in 2008. Consumption of various forms of alumina by the abrasives, chemicals, refractories, and other specialty industries accounted for the remainder of U.S. alumina use.

Prices

Most metallurgical-grade bauxite and alumina were purchased under long-term contracts, and contract terms normally were not made public. Spot prices for metallurgical-grade alumina and specialty forms of bauxite and alumina for nonmetallurgical applications, however, were published in trade journals.

The 2009 annual average values of U.S. imports of metallurgical-grade bauxite are listed in table 5. Alumina prices generally followed the trend in aluminum prices. Spot prices for metallurgical-grade alumina in international markets published by Metal Bulletin are listed in table 6. The 2009 average value of U.S. imports of calcined alumina was $330 per metric ton, cost, insurance, and freight at U.S. ports. Yearend price ranges for refractory-grade bauxite in China, 87% Al_2O_3 free on board (f.o.b.) ports, as quoted in Industrial Minerals (2009b), are listed in table 7.

World Industry Structure

Production.—In 2009, world production of bauxite decreased by 6% compared with that of 2008 (table 11). Mine production of 199 Mt was reported from 25 countries. The leading producers of bauxite, in decreasing order of tonnage mined, were Australia, China, Brazil, India, and Guinea. These countries accounted for 83% of total world production; Australia, China, and Brazil together accounted for more than two-thirds of the world's production.

World output of alumina decreased by 7% in 2009 compared with that of 2008 (table 12). The five leading producing countries, in descending order of quantity of alumina produced, were China, Australia, Brazil, India, and the United States. These countries accounted for more than three-quarters of world production; China and Australia together accounted for more than 57%.

Mergers, Acquisitions, and Restructuring.—Noranda Aluminum Holding Corp. (Franklin, TN) became the sole owner of Gramercy Alumina when it purchased Century Aluminum Co.'s (Monterey, CA) 50% share in the company. Renamed Noranda Alumina LLC, the company's assets include a 1.25-Mt/yr alumina refinery in Gramercy and a 4.8-Mt/yr bauxite mine in St. Ann, Jamaica (Noranda Aluminum Holding Corp., 2009b).

At the end of July, Alcoa completed the sale of its interest in Rio Tinto plc to Aluminum Corp. of China (Chinalco). In February 2008, Alcoa and Chinalco had jointly acquired 12% of the stock in Rio Tinto. A change in strategy in light of the economic conditions was cited by Alcoa as the reason for the sale (Alcoa Inc., 2009f).

Suriname Aluminum Co. (Suralco) (a subsidiary of Alcoa World Alumina and Chemicals Ltd.) purchased BHP Billiton Ltd.'s 45% share of the Suralco-BHP Billiton joint venture in Suriname, which included a 2.2-Mt/yr refinery at Paranam and associated bauxite mines (Alcoa Inc., 2009b).

As part of a financial restructuring deal, the Government of Montenegro received ownership of 29.4% of Kombinat Aluminijuma Podgorica and Bauxite Mines (KAP). Central European Aluminum Co. remained the managing partner with 29.4% ownership, with the remainder owned by other investors. Assets owned by KAP included a 120,000-t/yr smelter and a 280,000-t/yr alumina refinery in Podgorica and a 700,000-t/yr bauxite mine in Kutsko Brdo (Central European Aluminum Co., 2009, 2010).

World Review

Australia.—The Government of Australia was moving forward with a proposed cap-and-trade plan in an effort to reduce emissions of carbon dioxide and other greenhouse gases. The proposal included provisions for the aluminum and other emission-intensive industries to lower rates of carbon emissions during the first several years after enactment (Australian Department of Climate Change, 2009).

Work on the expansion project at the Worsley refinery continued on schedule despite the drop in alumina prices and the financial downturn. BHP Billiton was increasing capacity of the refinery to 4.6 Mt/yr from 3.5 Mt/yr, with completion projected in early 2011 (BHP Billiton Ltd., 2009b).

Rio Tinto announced that construction on the expansion project at the Yarwun refinery was delayed 2 years in response to the global financial downturn. The capacity of the refinery would increase to 3.4 Mt/yr from 1.4 Mt/yr when completed in the second half of 2012. Rio Tinto also reduced production of bauxite from the Weipa Mine to 15 Mt/yr from 19.4 Mt/yr at the start of 2010 (Rio Tinto plc, 2009b, c, p. 15).

In August, Bauxite Resources Ltd. (BRL) (Osborne Park, Western Australia) started production at its 3-Mt/yr bauxite mine in the Darling Range near Bindoon, Western Australia. Bauxite would be shipped by BRL to refineries in China and other customers in Asia through the ports at Kwinana and Bunbury. The company exported its first shipment of bauxite to China in November (Bauxite Resources Ltd., 2009a, b).

Chinalco continued a feasibility study of the Aurukun bauxite mine and refinery project, but by mid-2010 decided not to proceed with construction because of high costs and market conditions. The project would have included a 10-Mt/yr bauxite mine and a 2.1-Mt/yr alumina refinery. Chinalco said it was considering developing the project in the future if a deal with the Queensland government could be negotiated (Aluminum Corp. of China Ltd., 2009b; Wilson, 2010).

Azerbaijan.—OJSC Azerbaijan Aluminum shut down production from its Ghandja refinery during the second quarter in response to low alumina prices and high costs. The refinery had a capacity of 400,000 t/yr (CRU Alumina Monitor, 2009a).

Bosnia and Herzegovina.—Birac AD reduced the alumina production rate at its refinery to approximately 110,000 t/yr during the second quarter in response to low alumina prices and high costs. The refinery had a capacity of 600,000 t/yr (CRU Alumina Monitor, 2009a).

Brazil.—Alcoa World Alumina and Chemicals [a joint venture between Alcoa (60%) and Alumina Ltd. (40%)] opened the Juruti bauxite mine in September. At capacity, the mine was expected to produce 2.6 Mt/yr of bauxite. Bauxite from the mine would be sent to the Alumar refinery in São Luís, where an expansion project completed in July increased capacity to 3.6 Mt/yr from 1.5 Mt/yr. The refinery was expected to operate at full capacity during the first quarter of 2010. The refinery was a joint venture between Alcoa (38.4%), BHP Billiton (36%), Alumina (15.6%), and Rio Tinto (10%), with Alcoa being the refinery's operator (Alcoa, 2009c, d; BHP Billiton Ltd., 2009a).

Work continued on the construction of the Companhia de Alumina do Pará (CAP) alumina refinery in Barcarena. The refinery, expected to begin production by yearend 2012, would have an initial production capacity of 930,000 t/yr. An expansion to increase the refinery's capacity to 1.86 Mt/yr was also planned, although a construction schedule was not announced. The project was a joint venture among Vale SA (61%), Norsk Hydro ASA (Hydro) (20%), and Dubai Aluminium Co. Ltd. (Dubal) (19%). Vale also continued work on the Paragominas III mine. When completed in the second half of 2012, the mine would produce 4.95 Mt/yr of bauxite (Vale SA, 2009d, e).

Minerasção Rio do Norte S.A. (MRN) cut the bauxite production rate from its mines at Oriximina, Papagalo, and Trombetas to 15 Mt/yr from 19.8 Mt/yr in January in response to decreasing demand and lower prices for bauxite and alumina. The production rate decreased further in the second quarter, to 14.2 Mt/yr, before being increased to 16 Mt/yr during the third quarter as prices and demand stabilized and recovered slightly. MRN had a capacity to produce 19.8 Mt/yr of bauxite and was a joint venture among Vale (40%), BHP Billiton (14.8%), Alcoa (13.2%), Rio Tinto (12%), Companhia Brasileira de Aluminio (CBA) (10%), Hydro (5%), and Reynolds Aluminio do Brasil (5%) (Vale SA 2009a–c).

Novelis Inc. shut down production of alumina from its Ouro Preto refinery at the end of March. The refinery, which had supplied the adjacent Novelis smelter, was shut down because alumina could be purchased from other suppliers at less than the refinery's cost of production. The refinery had a production capacity of 150,000 t/yr (Novelis Inc., 2009).

Cameroon.—Cameroon Alumina Ltd. announced the discovery of a bauxite deposit with 550 Mt of reserves, located in the Adamawa region. The company was a joint venture between Dubal and Hindalco Industries Ltd. The company planned to open a mine in 2014 that would produce 4.5 to 9 Mt/yr and with an associated alumina refinery with a capacity of 1.4 to 3.0 Mt/yr. Rail infrastructure upgrades would be required to transport the bauxite or alumina 860 kilometers (534 miles) to the nearest port. Cameroon Alumina was applying for mining permits and negotiating with the Government about railroad upgrades. A feasibility study to be completed in 2012 was underway (Musa, 2009).

Canada.—Rio Tinto reduced the production rate of alumina from the Vaudreuil refinery to approximately 1 Mt/yr from 1.4 Mt/yr in the first quarter. In September, as prices for alumina increased, the production rate was increased to approximately 1.15 Mt/yr. The refinery in Jonquiere, Quebec, had a capacity of 1.4 Mt/yr (Rio Tinto plc, 2009a, c, p. 4, 15).

Exploration Orbite V.S.P.A. Inc. planned a pilot plant to test the recovery of alumina from aluminous clays near Grande-Vallee, Quebec. The clay contains approximately 23% alumina, and laboratory experiments have produced 99.8%-pure alumina. Preliminary exploration work of the deposit had been conducted but further exploration was planned to determine the size of the resource. Aluminerie Aloutte invested in the project and had tested samples of the alumina produced in the laboratory from the clay for use in its smelter (Exploration Orbite V.S.P.A. Inc., 2008a, b; Platts Metals Week, 2009a).

China.—In January, Henan Wanji Aluminum Co. Ltd. cut the production rate at its 800,000-t/yr refinery in Wanji, Henan Province, to approximately 400,000 t/yr. In April, the company increased the production rate to 640,000 t/yr. The shutdown and restart were in response to market conditions and prices for alumina (CRU Alumina Monitor, 2009e).

In February, Yangquan Coalmine Aluminium Co. Ltd. shut down 400,000 t/yr of capacity at its 1.6-Mt/yr refinery in Sanmenxia, Henan Province, as a result of decreasing prices and demand (Platts Metals Week, 2009b).

In August, Guangxi Huayin Aluminum Co. Ltd. restarted capacity that had been shut down in late 2008 at its refinery in Huayin, Guangxi Province. The restart of 1.6 Mt/yr of capacity as enabled by higher alumina prices (CRU Alumina Monitor, 2009g).

In January, Datung International Power Generation Co. completed construction of a refinery to produce alumina from coal ash. The refinery in Datong, Shanxi Province, had a capacity of 3,000 t/yr and would use coal ash from Nei Mongol Province, which had an alumina content of nearly 50% (Hornby, 2009).

East Hope Group Ltd. delayed startup of the expansion of its refinery in Sanmenxia. The project increased capacity of the refinery to 2.0 Mt/yr from 1.5 Mt/yr. Market conditions were cited as a reason for the delayed startup. A decision on constructing an additional expansion to 2.5 Mt/yr was postponed until market conditions improved (Platts Metals Week, 2009e).

Chinalco was progressing with construction of a refinery in Nanchuan, Chongqing Province, that would have a capacity of 800,000 t/yr when completed in 2010. Chinalco was also progressing on an 800,000-t/yr refinery in Zunyi, Guizhou Province, that was expected to be completed in 2010 (Aluminum Corp. of China Ltd., 2009a, p. 81–83).

Henan Yima Group Ltd. was constructing a 400,000-t/yr alumina refinery in Yima, Henan Province, and planned to start production early 2010 (CRU Alumina Monitor, 2009j).

Louyang Xiangjiang Wanji Aluminium Ltd. started work on an expansion project at its alumina refinery in Louyang, Henan Province. Capacity would increase to 1.4 Mt/yr from 800,000 t/yr when completed at the end of 2011. Further expansion to increase capacity to 2.0 Mt/yr was proposed, although a schedule was not available (Platts Metals Week, 2009f).

Guizhou Guanglu Aluminium Co. started construction of an 800,000-t/yr alumina refinery in Qingzhen, Guizhou Province. The project was scheduled for completion by 2012 with production at full capacity expected by mid-2012. The company also started construction of a nearby mine to supply bauxite to the refinery. The mine would have a capacity of 1.6 Mt/yr when completed at the beginning of 2012 (Platts Metals Week, 2009c).

Melicsea Erdos Alumina Co. Ltd. started construction of a refinery that would produce alumina from coal ash. The 400,000-t/yr refinery located in Ordos, Nei Mongol Autonomous Region, was expected to begin production by early 2010 (CRU Alumina Monitor, 2009e).

Zhengzhou Coal Group Co. announced plans to construct an 800,000-t/yr alumina refinery in Yuncheng, Shanxi Province, although a schedule was not announced. Bauxite mined from areas adjacent to the refinery would be processed at the refinery (CRU Alumina Monitor, 2009f).

Bosai Minerals Group Co. Ltd. announced that it would expand capacity of its alumina refinery in Sichuan Province to 500,000 t/yr from 200,000 t/yr by mid-2010 (CRU Alumina Monitor, 2009g).

A reported 80-Mt bauxite deposit was discovered near the city of Zunyi, Guizhou Province, and construction of an 800,000-t/yr refinery was to start at yearend 2010, although a completion date was not available (CRU Alumina Monitor, 2009e).

France.—In January, Rio Tinto announced that the production rate of specialty alumina from the Gardanne refinery would be reduced to approximately 300,000 t/yr from 550,000 t/yr in response to declining demand and lower prices for alumina. Production of smelter-grade alumina had been shut down during the fourth quarter of 2008 (Rio Tinto plc, 2009a, c, p. 4, 15).

Ghana.—In April, Rio Tinto temporarily cut the production rate at the Awaso bauxite mine to 110,000 t/yr from 870,000 t/yr as a result of lower prices and reduced demand for bauxite and alumina. The mine, with a capacity of 1.0 Mt/yr, was a joint venture between Rio Tinto (80%) and the Government of Ghana (20%) (Rio Tinto plc, 2009c, p. 4, 15).

Guinea.—The Government was taking action to nullify the sale of the Friguia refinery to United Company RUSAL (Rusal) that was negotiated by the prior regime in 2006. The Government was also demanding that Rusal and other mining companies employ fewer expatriot professionals and hire qualified Guinean citizens at mines throughout the country (Mukumbira, 2009).

In October, workers at mines across Guinea called a general strike to protest violence by the military that killed more than 150 people who had been protesting against the Government. The strike lasted 2 days and was organized by groups opposed to the military-led Government (Samb, 2009).

Rusal cut alumina production from the 640,000-t/yr alumina refinery at Friguia by 11% compared with production in 2008 as a result of declining demand and lower prices. Bauxite production from the Friguia and Kinda mines also declined by 15% compared with production in 2008 (United Company RUSAL, 2010).

In March, the bauxite production rate was cut at the Sangaredi mine to 8.3 Mt/yr from 13.5 Mt/yr as a result of lower prices and declining demand for bauxite and alumina. The mine, with a capacity of 14 Mt/yr, was a joint venture among the Government

(49%), Rio Tinto (22.95%), Alcoa (22.95%), and Dadco Group (5.1%) (Rio Tinto plc, 2009c, p. 4, 15).

Global Alumina Corp. was reviewing the construction schedule of its bauxite mine and alumina refinery project. The project was still in the feasibility stage, and construction was delayed at least until the end of 2010, with completion not expected until 2014. The refinery would have a capacity of 3.3 Mt/yr and would use bauxite from deposits for which Global Alumina had mining concessions. The project was a joint venture with BHP Billiton, Dubal, and Mubadala Development Co. (Global Alumina Corp., 2009).

Navasota Resources Ltd.'s exploration project on its concession in the Boke Bauxite Belt reported bauxite reserves of 343 Mt and an additional 63 Mt of inferred resources (Navasota Resources Ltd., 2009).

Guyana.—Bosai informed the Government that construction of a 1-Mt/yr alumina refinery, scheduled to begin in 2009, would be delayed as a result of the credit crisis and depressed alumina prices. The refinery would probably be built in two stages after construction is rescheduled and would be a joint venture between Bosai (70%) and the Government (30%) (Media Corp. Pte. Ltd., 2009).

In May, Bosai cut production of refractory-grade bauxite by 30% at its Linden Mine as a result of reduced demand and lower prices, but restored production in September when demand increased. Bosai owned 70% of the mine, with the Government owning 30% (Habibullah, 2009; Industrial Minerals, 2009a).

Rusal reduced production at the Kwakwani bauxite mine by 23% compared with production in 2008 as a result of reduced demand and lower prices for bauxite and alumina (United Company RUSAL, 2010). In addition, Rusal placed on hold construction scheduled to start in 2011 on an alumina refinery and an aluminum smelter powered by a hydroelectric plant (Media Corp. Pte. Ltd., 2009).

India.—National Aluminum Co. of India Ltd. (Nalco) completed the expansion project at its refinery in Damanjodi, which increased capacity to 2.1 Mt/yr from 1.6 Mt/yr (National Aluminum Co. Ltd., 2009, p. 14). Commissioning of the new line had been scheduled for July but was delayed as a result of attacks in the area by Maoist insurgents. Nalco planned to start production by early 2010, depending on the security situation in the region (Platts Metals Week, 2009d).

Hindalco continued progress on several major expansion projects. The Belgam refinery was ramping up production to 316,000 t/yr from 138,000 t/yr. Construction of the 1.5-Mt/yr Utkal alumina refinery was continuing, with production scheduled to start in July 2011. Planning continued for the Aditya aluminum complex in Orissa, which would have a 359,000-t/yr smelter, a 1.5-Mt/yr alumina refinery, and a 900-megawatt (MW) captive powerplant. Funding for about one-half of the cost for the smelter and powerplant was committed. Completion of the construction of the smelter was planned for October 2011, although completion of the construction of the refinery was revised to June 2013 from January 2013 (Hindalco Industries Ltd., 2009).

Vedanta Resources plc ramped up the first phase of its 1.4-Mt/yr Lanjigarh refinery to full capacity at the beginning of 2009. The second phase of the refinery was completed and production was initiated during the first quarter of 2009. Work was progressing to increase capacity to 2.0 Mt/yr by March 2010, and Vedanta planned to expand capacity further to 5.0 Mt/yr by mid-2011. Construction was progressing on the Niyamgiri bauxite mine, expected to be the main source of bauxite for the Lanjigarh refinery, with completion projected by mid-2010 (Vedanta Resources plc, 2009, p. 13).

Anrak Aluminium Ltd. was progressing with plans to construct a 1.5-Mt/yr alumina refinery, a 250,000-t/yr aluminum smelter, and a 900-MW powerplant in Vishakhapatnam, Andhra Pradesh. A construction schedule was not available (CRU Alumina Monitor, 2009c, i).

JSW Steel Ltd. was progressing with plans to construct a 1.4-Mt/yr alumina refinery in Andhra Pradesh. The project was delayed during the first quarter of 2009 until a new source of financing was obtained later in the year. A revised construction schedule was not available (CRU Alumina Monitor, 2009c, i).

Ashapura Minechem Group Ltd. was planning to construct an aluminum complex in Rataigiri, Maharashtra. The complex would include a 500,000-t/yr alumina refinery, a 150,000-t/yr aluminum smelter, and a 330-MW captive powerplant. A construction schedule was not available (CRU Alumina Monitor, 2009c).

Indonesia.—PT Aneka Tambang (Antam) deferred plans to construct a 300,000-t/yr refinery in Tayan indefinitely as a result of market conditions and rising costs of construction. Antam was proceeding with the development of a 400,000-t/yr bauxite mine in Tayan. A completion date was not available (CRU Alumina Monitor, 2009h).

Iran.—Construction of a 200,000-t/yr alumina refinery in Sarab continued on schedule for completion by the end of 2010. Nepheline syenite would be the raw material used by the refinery that would also produce potassium carbonate and sodium carbonate as byproducts. Deposits in the two provinces near the refinery have been estimated to contain 4 to 6 billion metric tons of nepheline syenite (Mehrabian, 2009).

Ireland.—Rusal reduced the production rate at the Aughinish alumina refinery in the first quarter to 1.13 Mt/yr in response to low alumina prices. The refinery had a capacity of 1.5 Mt/yr (United Company RUSAL, 2009b, c).

Italy.—Rusal shut down the Eurallumina alumina refinery on the island of Sardinia in the first quarter of the year. Low alumina prices were cited for the closure of the 1.1-Mt/yr refinery (United Company RUSAL, 2009b, c).

Jamaica.—In February, bauxite production at Century's St. Ann Mine was cut to approximately 1.25 Mt/yr from 4.5 Mt/yr. Alumina production was reduced at the mine's exclusive customer, the refinery at Gramercy, LA, because the New Madrid, MO, aluminum smelter, which was one of Gramercy's main customers, shut down 75% of its production in January as a result of a power loss. Price declines for alumina were also cited for the production cut. After Century sold its share of the St. Ann Mine to Noranda in September, Noranda announced that it would increase production at the mine to full capacity by yearend, as output from the Gramercy refinery and the New Madrid smelter returned to full capacity (Noranda Aluminum Holding Corp., 2009a, b).

In January, Rusal and Hydro temporarily reduced the production rate by 825,000 t/yr from 1.65-Mt/yr at the Alpart alumina refinery in Nain and the nearby bauxite mine. In May, all production from the refinery and mine was closed. Rusal stated that the closure was expected to last for at least 1 year, citing the decline in prices for alumina and aluminum (Norsk Hydro ASA, 2009; United Company RUSAL, 2009a). Rusal also shut down the 3.9-Mt/yr Windalco Mine and the 650,000-t/yr Ewarton and 560,000-t/yr Kirkvine refineries in the first quarter (United Company RUSAL, 2009b).

Montenegro.—After financial restructuring, Central European Aluminum continued modernizing the Podgorica alumina refinery and aluminum smelter. The capacity of the alumina refinery would increase to 400,000 t/yr from 280,000 t/yr, and the capacity of the smelter would increase to 156,000 t/yr from 120,000 t/yr. Completion of the modernization projects was expected by yearend 2010 (Central European Aluminum Co., 2009, 2010).

Romania.—Vimetco NV restarted production from the Alum alumina refinery at Tulcea in October. The refinery had been closed since February 2007 for an expansion and modernization project to increase capacity to 600,000 t/yr from 500,000 t/yr and to upgrade emissions control systems to be compliant with environmental regulations (Vimetco NV, 2009).

Russia.—Rusal cut production from its alumina refineries in Russia by 10% compared with alumina production in 2008 as a result of lower prices. Most of the cuts were from the 1.1-Mt/yr Achinsk and 200,000-t/yr Boksitogorsk refineries, which were cited as having higher production costs than other refineries in Russia owned by Rusal. The production cuts were made during the first half of 2009. Bauxite production by Rusal in Russia was slightly higher than that of 2008 (United Company RUSAL, 2010).

As a result of financing constraints, Rusal announced plans to slow work on the Komi refinery project. The refinery would have a capacity of 1.4 Mt/yr and was previously planned to start production by the end of 2009. A revised construction schedule was not released (United Company RUSAL, 2009b).

Saudi Arabia.—Alcoa and Saudi Arabian Mining Co. (Ma'aden) formed a joint venture to construct an aluminum complex with a 4.0-Mt/yr bauxite mine, 1.8-Mt/yr alumina refinery, 740,000-t/yr smelter, and a rolling mill. The mine would be at Al Ba'itha, with bauxite transported by rail to Raz Az Zawr, where the refinery, smelter, and rolling mill would be built. Startup of the smelter and rolling mill using purchased alumina were expected in 2013, and production from the mine and refinery would begin in 2014. Alcoa would own 20% of the operation, with Ma'aden owning 60% and other partners owning the remaining 20% (Alcoa Inc., 2009a). Ma'aden had previously had a joint venture with Rio Tinto for the project, but Rio Tinto canceled its participation in the project amid financing constraints (Rio Tinto Alcan Inc., 2008).

Suriname.—Suralco announced that the alumina production rate at the 2.2-Mt/yr refinery in Paranam would be reduced by 40% to 1.3 Mt/yr. Reduced demand and lower prices for alumina and aluminum were cited as the reasons for the temporary production cut (Alcoa Inc., 2009e).

Ukraine.—Rusal shut down alumina production in the first quarter from the Zaporozhye refinery. The 227,000-t/yr refinery was cited as having higher costs than other refineries owned by Rusal (United Company RUSAL, 2010).

Venezuela.—The production rate from Corporacion Venezolana de Guayana Bauxilum C.A.'s (Bauxilum) Los Pijiguaos bauxite mine was cut to one-half of its 6-Mt/yr capacity early in the year as a result of shortages of fuel and replacement parts for equipment. In October, Bauxilum obtained funding for equipment repairs and other investments at the mine. Bauxilum reduced production of alumina from the Puerto Ordaz refinery as a result of the bauxite shortage and stopped exporting alumina in September, shipping alumina only to smelters in Venezuela (Beltran, 2009a, b).

Vietnam.—Vietnam Coal Industry Group and Shandong Aluminium Engineering Co. started construction of a 600,000-t/yr alumina refinery at the beginning of 2009. The refinery would be located in Hu Zhiming City, Lintong Province. A construction schedule was not available (CRU Alumina Monitor, 2009b).

Vietnam National Coal and Mineral Industries Group (Vinacomin) and Chinalco signed a contract for construction of a 600,000-t/yr alumina refinery in Nhan County, Dak Nong Province. The refinery was scheduled to be completed in 2011 (CRU Alumina Monitor, 2009d).

Alcoa and Vinacomin were conducting a feasibility study of a joint-venture 600,000-t/yr alumina refinery in Gia Nghia, Dak Nong (CRU Alumina Monitor, 2009e).

Atlantic Ltd. signed a memorandum of understanding with state-owned Vietnam Natural Resources and Environment Corp. to develop a bauxite mine and associated infrastructure. Atlantic would conduct exploration of bauxite deposits in Dak Nong and Lam Dong Provinces with the aim of developing a 25-Mt/yr mine. Studies for a refinery and smelter would also be conducted if a mine proved feasible (Atlantic Ltd., 2009).

Outlook

Consumption of bauxite and alumina was expected to closely follow the trends of the aluminum market. Although demand and prices for bauxite and alumina had stabilized after the global financial crisis during late 2008 and early 2009, consumption and prices were at a lower level than prior to the downturn. Consumption was expected to remain in a lower range until economic growth was reestablished. While some domestic alumina refinery capacity had been restarted during 2009, further restarts at domestic refineries were not projected until aluminum prices increase substantially. Globally, restarts at refineries and bauxite mines also were not anticipated until a sustained economic recovery was evident.

Although consumption was recovering from the low levels reached during the crisis, decreased demand for aluminum in developed economies still recovering from the economic events of 2008 could keep global aluminum production, and hence bauxite and alumina production, below the record-high 2008 production until at least 2012. Consumer credit issues in the United States and Western Europe were expected to continue through 2010. The uncertainty of the impact of sovereign debt issues in Europe also raised concerns about consumer demand.

Demand for aluminum in emerging economies was expected to increase as these economies continue to grow and recover from the effects of the global recession. However, policies aimed at restraining construction in China may slow the rate of growth of demand for aluminum in that nation. Lack of credit was expected to continue to cause delays in expansion projects at mines and refineries in many parts of the world, although projects in places with high-grade bauxite reserves were expected to move forward.

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TABLE 1

SALIENT BAUXITE STATISTICS[1]

(Thousand metric tons)

	2005	2006	2007	2008	2009
United States:					
Exports, as shipped:					
Crude and dried	34	20	15	14	9
Calcined	18	14	8	10	8
Imports for consumption, as shipped:					
Crude and dried	11,800	11,600	9,840	10,500	6,970
Calcined	818	752	808	1,110	461
Consumption, dry equivalent	12,400	12,300	10,200	9,550	6,620
World, production	178,000 r	193,000 r	204,000 r	211,000 r	199,000 e

eEstimated. rRevised.

[1] Data are rounded to no more than three significant digits.

TABLE 2
SALIENT ALUMINA STATISTICS[1]

(Thousand metric tons)

	2005	2006	2007	2008	2009
United States:					
Production:					
Calcined alumina	4,750	4,610	3,770	3,900	2,760
Other alumina[2]	708	618	717	610	471
Total:					
As produced or shipped[3]	5,460	5,230	4,490	4,510	3,230
Calcined equivalent	5,220	5,010 [r]	4,240	4,300	3,060
Shipments:					
Calcined alumina	4,760	4,580	3,770	3,910	2,760
Other alumina[2]	658	564	667	582	464
Total:					
As produced or shipped[3]	5,420	5,150	4,440	4,490	3,230
Calcined equivalent	5,190	4,950 [r]	4,200 [r]	4,290 [r]	3,060
Stocks, yearend[4, 5]	834	942	437	636	175
Imports for consumption[5]	1,860	1,860	2,440	2,530	1,860
Exports[5]	1,210	1,540	1,160	1,150	946
Consumption[5, 6]	5,750	5,220	6,020	5,490	4,430
World, production[5]	65,000 [r]	72,300 [r]	77,700 [r]	82,600 [r]	76,400 [e]

[e] Estimated. [r] Revised.

[1] Data are rounded to no more than three significant digits.

[2] Trihydrate, activated, tabular, and other aluminas. Excludes calcium and sodium aluminates.

[3] Includes only the end product if one type of alumina was produced and used to make another type of alumina.

[4] Excludes consumers stocks other than those at primary aluminum plants.

[5] Calcined equivalent.

[6] Defined as domestic production plus imports minus exports plus adjustments for industry changes.

TABLE 3
CAPACITIES OF DOMESTIC ALUMINA PLANTS, DECEMBER 31[1, 2]

(Thousand metric tons per year)

Company and plant	2008	2009
Alcoa Inc., Point Comfort, TX	2,300	2,300
Noranda Alumina LLC, Gramercy, LA[3]	1,250	1,250
Ormet Corp., Burnside, LA	600	600
Sherwin Alumina Co., Corpus Christi, TX[4]	1,600	1,600
Total	5,750	5,750

[1] Capacity may vary depending on the bauxite used.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Owned by Noranda Aluminum Holding Corp., a subsidiary of Apollo Management LP.

[4] Owned by Glencore International AG.

TABLE 4
U.S. CONSUMPTION OF BAUXITE, BY INDUSTRY[1]

(Thousand metric tons, dry equivalent)

Industry	2008	2009
Alumina	9,310	6,480
Other[2]	234	142
Total	9,550	6,620

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes abrasive, chemical, and refractory uses.

TABLE 5
AVERAGE VALUE OF U.S. IMPORTS OF CRUDE AND DRIED BAUXITE[1]

(Dollars per metric ton)

	2008		2009	
Country	Port of shipment f.a.s.[2]	Delivered to U.S. ports c.i.f.[3]	Port of shipment f.a.s.[2]	Delivered to U.S. ports c.i.f.[3]
Brazil	38.66	53.37	35.53	48.84
Guinea	35.04	47.50	32.69	46.86
Guyana	37.11	52.69	42.50	65.31
Jamaica	21.35	26.02	20.78	24.24
Sierra Leone	34.85	47.35	29.49	47.35
Weighted average	26.43	35.92	29.80	37.10

[1] Computed from quantity and value data reported to U.S. Customs Service and compiled by the U.S. Census Bureau. Not adjusted for moisture content of bauxite or differences in methods used by importers to determine value of individual shipments.

[2] Free alongside ship valuation.

[3] Cost, insurance, and freight valuation.

TABLE 6
ALUMINA PRICES[1]

(Dollars per metric ton)

	2008	2009
January	350–370	170–200 [e]
February	390–420	170–200
March	390–420	170–185
April	400–420	200–230
May	400–421	200–220
June	420–450	210–230
July	420–450	240–250
August	390–400	290–300
September	350–370	290–325
October	290–340	295–315
November	210–240	295–315
December	210–240	295–315

[e] Estimated.

[1] Material: Metallurgical grade, free market, spot range, free on board ship valuation, month end.

Source: Metal Bulletin.

TABLE 7
REFRACTORY GRADE BAUXITE PRICES[1]

(Dollars per metric ton)

Material	2008	2009
China:		
Guizhou Province, rotary kiln, lump	410–430	390–410
Shanxi Province, rotary kiln, lump	610–620	470–500
Shanxi Province, round kiln, lump	610–620	480–500
Guyana, rotary kiln, lump	540–570	450–510

[1] Material, port, 88% Al_2O_3, free on board ship valuation, yearend.

Source: Industrial Minerals.

TABLE 8
U.S. EXPORTS AND IMPORTS FOR CONSUMPTION OF BAUXITE, CRUDE AND DRIED, BY COUNTRY[1]

(Thousand metric tons)

Country	2008	2009
Exports:		
Canada	8	17
Germany	1	(2)
Ireland	3	--
Venezuela	1	(2)
Other	2	3
Total	14	20
Imports:		
Brazil	1,940	1,410
Guinea	2,350	1,910
Guyana	723	80
Jamaica[3]	4,430	3,200
Sierra Leone	779	308
Other	260	72
Total	10,500	6,970

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

[3] Data from the Jamaica Bauxite Institute.

Note: Total U.S. imports of crude and dried bauxite as reported by the U.S. Census Bureau were as follows: 2008—9.94 million metric tons (Mt) and 2009—6.97 Mt.

Source: U.S. Census Bureau.

TABLE 9
U.S. EXPORTS AND IMPORTS FOR CONSUMPTION OF CALCINED BAUXITE, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2008				2009			
	Refractory grade		Other grade		Refractory grade		Other grade	
Country	Quantity	Value[2]	Quantity	Value[2]	Quantity	Value[2]	Quantity	Value[2]
Exports:								
Canada	7	727	(3)	9	7	748	(3)	30
Korea, Republic of	--	--	--	--	11	8,800	--	--
Mexico	1	525	(3)	130	(3)	563	(3)	602
Other	1	84	(3)	123	1	126	(3)	17
Total	9	1,340	1	262	20	10,200	1	649
Imports:								
Australia	--	--	162	3,430	--	--	17	1,040
Brazil	125	58,500	27	2,590	114	54,300	46	1,700
China	177	63,100	66	14,300	12	--	11	5,980
Greece	28	1,610	--	--	74	3,850	--	--
Guyana	39	13,800	305	14,500	21	8,640	164	9,510
Other	1	100	178	6,490	(3)	6,390	1	344
Total	370	137,000	738	41,300	222	73,200	239	18,600

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Value at foreign port of shipment as reported to U.S. Customs Service.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 10
U.S. EXPORTS AND IMPORTS FOR CONSUMPTION OF ALUMINA, BY COUNTRY[1]

(Thousand metric tons, calcined equivalent, and thousand dollars)

	2008		2009	
Country	Quantity	Value[2]	Quantity	Value[2]
Exports:				
Canada	629	244,000	332	109,000
France	--	--	125	37,800
Iceland	311	99,100	277	63,200
Mexico	54	39,100	57	38,000
Netherlands	28	17,300	2	7,750
Norway	34	13,300	79	17,100
Other	93	272,000	73	215,000
Total	1,150	684,000	946	488,000
Imports:				
Australia	930	307,000	703	159,000
Brazil	523	207,000	367	87,300
Jamaica	468	173,000	248	62,300
Suriname	264	86,500	381	90,300
Venezuela	154	66,300	--	--
Other	195	264,000	159	214,000
Total	2,530	1,100,000	1,860	613,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Value at foreign port of shipment as reported to U.S. Customs Service.

Source: U.S. Census Bureau.

TABLE 11
BAUXITE: WORLD PRODUCTION, BY COUNTRY[1,2]

(Thousand metric tons)

Country	2005	2006	2007	2008	2009[e]
Australia	59,959	61,780	62,398	61,389	65,231 [3]
Bosnia and Herzegovina	1,032	854	867	1,018 [r]	850
Brazil	22,034	23,236 [r]	25,461 [r]	28,098 [r]	28,200 [p]
China[e]	22,000	27,000	30,000	35,000	40,000
Dominican Republic	535 [3]	500	500	400	--
Ghana	607	842	748	796 [r]	440 [3]
Greece	2,495	2,163	2,126 [r]	2,176 [r]	2,100
Guinea[4]	16,817	18,784	18,519	18,400 [r]	15,600
Guyana[4]	1,694 [r]	1,479 [r]	2,243 [r]	2,092 [r]	1,760 [3]
Hungary	535 [e]	538	546	511 [r]	317
India	12,385	13,940	20,343	21,210	16,000
Indonesia	1,442	1,502	1,251	1,152 [r]	1,200
Iran	438 [3]	500	500	500	500
Jamaica[4, 5]	14,116	14,865	14,568	14,363 [r]	7,817 [3]
Kazakhstan	4,815	4,884	4,943	5,160 [r]	5,130 [3]
Malaysia	5	92	157	295 [r]	280
Montenegro	672 [6]	659	667	672	46 [3]
Mozambique	10	11	9	5 [r]	4 [3]
Pakistan	7	7	8	8	7
Russia	5,000 [r, e]	6,300 [r]	5,775 [r]	5,675 [r]	5,775 [3]
Sierra Leone	--	1,071	1,169	954	757 [3]
Suriname	4,757	4,924	5,054 [r]	5,200 [r]	4,000 [3]
Tanzania	2	5	5	5 [e]	5
Turkey[7]	475	771	344	350 [e]	330
United States	NA	NA	NA	NA	NA
Venezuela	5,900	5,928	5,500 [r]	5,500 [e]	2,500
Vietnam[e]	26 [3]	30	30	30	30
Total	178,000 [r]	193,000 [r]	204,000 [r]	211,000 [r]	199,000

[e] Estimated. [p] Preliminary. [r] Revised. NA Not available. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 29, 2010.

[3] Reported figure.

[4] Dry bauxite equivalent of crude ore.

[5] Bauxite processed for conversion to alumina in Jamaica plus kiln-dried ore prepared for export.

[6] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[7] Public-sector production only.

TABLE 12
ALUMINA: WORLD PRODUCTION, BY COUNTRY[1, 2, 3]

(Thousand metric tons)

Country	2005	2006	2007	2008	2009
Australia	17,704	18,312	18,844	19,321	19,948
Azerbaijan	315	363	185	165 r	10
Bosnia and Herzegovina	450	390	304	294 r	120 e
Brazil	5,300	6,793	6,890	7,889 r	8,000 p
Canada	1,214	1,281	1,300 e	1,370 r	1,125
China e	8,610	13,700	19,500	22,800	23,800
France e	600 r	600 r	600 r	630 r, 4	348 4
Germany	1,255	1,393	1,388	1,395	1,154
Greece e	750	750	750	750	780
Guinea	740	530 r	527 r	593 r	530
Hungary	305 r	301 r	301 r	299 r	185
India e	2,700	2,800	2,900	3,000	3,700
Iran e	200	250	250	200 r	250
Ireland	1,800 r	1,816 r	1,803 r	1,890 r	1,245
Italy	1,093	1,103 r	1,069 r	1,045 r	92
Jamaica	4,086	4,099	3,941	3,996 r	1,774
Japan e, 5	350	330	300	320	310
Kazakhstan	1,505	1,515	1,556	1,600 r	1,608
Montenegro	235 6	237 r	240	220	59
Romania	689	622	23 7	--	44
Russia	3,259	3,265	3,333 r	3,112 r	2,794
Slovakia	-- r	-- r	-- r	-- r	--
Slovenia	-- r	-- r	-- r	-- r	--
Spain e, 8	1,000 r	1,000 r	1,500 r	1,500 r	1,500
Suriname	1,944	2,153	2,270 r	2,156 r	1,178
Turkey e	113 4	150 4	160	160	150
Ukraine	1,632	1,672	1,656 r	1,673 r	1,524
United Kingdom	-- r	-- r	-- r	-- r	--
United States	5,220	5,010 r	4,240	4,300	3,060
Venezuela e	1,920 4	1,892 4	1,900	1,900	1,100
Total	65,000 r	72,300 r	77,700 r	82,600 r	76,400 e

e Estimated. p Preliminary. r Revised. -- Zero.

[1] Figures represent calcined alumina or the total of calcined alumina plus the calcined equivalent of hydrate when available; exceptions, if known, are noted.

[2] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[3] Table includes data available through July 29, 2010.

[4] Reported figure.

[5] Data presented are for alumina used principally for specialty applications. Information on aluminum hydrate for all uses is not adequate to formulate estimates of production levels. Production of aluminum hydroxide, in metric tons: 2005—740,000; 2006—720,000; 2007—700,000; 2008—700,000; and 2009—710,000.

[6] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[7] Plant closed January 2007.

[8] Hydrate.

BERYLLIUM

By Brian W. Jaskula

Domestic survey data and tables were prepared by Joseph M. Krisanda, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

U.S. mine shipments of beryllium ore in 2009 decreased 31% from those of 2008, and ore consumption for the production of beryllium hydroxide decreased 32% (table 1). The Defense National Stockpile Center (DNSC) of the U.S. Department of Defense (DOD) offered and sold selected beryllium materials from the National Defense Stockpile (NDS). On the basis of estimated contained beryllium, total U.S. imports and exports of beryllium materials were lower than those of 2008.

Beryl is frequently stockpiled for later processing. China is thought to be a significant producer, but does not report its beryl production. As a result, world production and the U.S. share of world production have a high degree of uncertainty. In 2009, estimated world beryllium mine production decreased by 27% compared with that of 2008 (table 4). The United States accounted for about 84% of estimated world production.

Beryllium is gray in color and one of the lightest metals. Its other physical and mechanical properties—outstanding stiffness-to-weight and strength-to-weight ratios, one of the highest melting points of all light metals, high specific heat, excellent thermal conductivity, outstanding dimensional stability over a wide range of temperatures, reflectivity, the lowest neutron absorption cross section of any metal and a high neutron-scattering cross section, and transparency to x rays—make it useful for many applications. Beryllium is used primarily as beryllium-copper alloys, beryllium oxide ceramics, and beryllium metal in a wide variety of products in aerospace, automotive (ignition components), computer (computer chip heat sinks), defense, electronics (highly conductive and strong wire), heavy machinery, home appliance (microwave guides), industrial component (bearings and bushings), instrumentation and control system, medical, nuclear, oil and gas drilling, plastic molding, telecommunications, undersea and marine, and other applications.

Only two beryllium minerals are of commercial importance for the production of beryllium. Bertrandite, which contains less than 1% beryllium, is the principal beryllium mineral mined in the United States. Beryl, which contains about 4% beryllium, is the principal mineral mined in the rest of the world. Aquamarine, bixbite, emerald, goshenite, heliodor, and morganite are gem forms of the mineral beryl. More information on gem-quality beryl and chrysoberyl can be found in the Gemstones chapter of the U.S. Geological Survey (USGS) Minerals Yearbook, volume I, Metals and Minerals.

Legislation and Government Programs

Strategic Materials Protection Board.—The U.S. Department of Defense Strategic Materials Protection Board (comprised of representatives from the Office of the Secretary of Defense; the Under Secretary of Defense for Acquisition, Technology, and Logistics; the Under Secretary of Defense for Intelligence; and the Secretaries of the Air Force, Army, and Navy) ruled that high-purity beryllium was both a strategic and a critical material, that domestic beryllium production capabilities had abated, and required the DOD to continue to take special actions to maintain a long-term domestic supply (Metal-Pages, 2009; U.S. Department of Defense, 2009).

Defense Production Act.—DOD, under its Defense Production Act Title III Program with Brush Wellman Inc. [a subsidiary of leading beryllium producer Brush Engineered Materials Inc. (BEM)], entered phase 2 of its Technology Investment Agreement for the construction and startup of a $90.3 million primary beryllium facility in Elmore, OH. The objective of the partnership between DOD and Brush Wellman was to ensure a long-term domestic supply of primary beryllium, the feed material used to make beryllium metal products. Brush Wellman was to fund approximately $23.2 million of the project, with the remaining balance to be funded by DOD. Construction was expected to be completed by mid-2010 (Smith Horn, 2008; Brush Engineered Materials Inc., 2010a, p. 39).

National Defense Stockpile.—The United States maintained a stockpile of strategic materials for use during a national emergency. As of December 31, 2009, the NDS goal for hot-pressed beryllium metal powder was 45 metric tons (t) (table 2). However, a goal of 155 t of hot-pressed beryllium metal powder had been proposed in the 2003 National Defense Stockpile Requirements Report to the Congress. The Annual Materials Plan for fiscal year 2009, which represented the maximum quantities of beryllium materials that could be sold from October 1, 2008, through September 30, 2009, was as follows: 1,000 t of beryl ore (36 t of beryllium content), actual quantity limited to remaining sales authority or inventory; 300 t of beryllium-copper master alloy (BCMA) (11 t of beryllium content), actual quantity limited to remaining sales authority or inventory; and 36 t of beryllium metal (table 2). The DNSC shipped 19 t of beryllium metal in 2009. NDS calendar yearend inventories of beryllium materials are listed in table 2 (U.S. Department of Defense, 2010, p. 6).

Production

Domestic production and consumption statistics for beryllium-containing ores, as listed in tables 1 and 4, were based on data collected by the USGS by means of two voluntary surveys of U.S. operations. A small number of unidentified producers may have shipped negligible quantities of byproduct beryl, but these have not been included. In 2009, domestic mine shipments were less than those of 2008.

The United States is one of only three countries known to process beryllium ores and concentrates into beryllium products. Brush Resources Inc. (a subsidiary of BEM) converted bertrandite from open pit mines in the Topaz-Spor Mountain region of Juab County, UT, along with imported beryl and beryl from the NDS, into beryllium hydroxide at its operations near Delta, UT. Some of the beryllium hydroxide was shipped to Elmore, where Brush Wellman converted it into BCMA, metal, or oxide, and some was sold to NGK Insulators, Ltd. of Japan.

As part of its effort to become a vertically integrated supplier of beryllium products, IBC Advanced Alloys Corp. (Vancouver, British Columbia, Canada) focused on three distinct business areas in 2009: beryllium exploration, downstream manufacturing of beryllium products, and beryllium research. In 2008, to support its beryllium exploration effort, IBC acquired Rare Earths Ltd. (REL), a Colorado-based beryllium exploration company. Also in 2008, IBC acquired the Boomer Mine, located in Park County, CO, and completed the staking of 517 beryllium mineral claims in the Lake George District of Colorado, an area that included the Boomer Mine (International Beryllium Corp., 2008a, b, c).

In 2009, IBC, in partnership with Purdue University and Texas A&M University, continued research into a new type of beryllium oxide (BeO) enhanced nuclear fuel. IBC was funding a 2-year, $500,000 research project by Purdue University's Department of Nuclear Engineering to investigate the possibility of producing a longer lasting, more efficient, and safer nuclear fuel pellet by the addition of BeO to the uranium oxide pellet. Currently produced uranium oxide fuels, while stable and safe, are not efficient at conducting heat, which limits the power generated and causes fuel pellets to crack and degrade prematurely, necessitating replacement before the fuel has been entirely used. The addition of BeO may help cool the fuel pellet, allowing it to operate at a lower temperature and be used for a longer time, resulting in a more efficient burning of the fuel. A lower temperature would also allow for safer, more flexible reactor operation. If successful, the BeO-enhanced nuclear fuel pellet could increase demand for beryllium substantially (Mandel, 2008; Venere and Sequin, 2008; IBC Advanced Alloys Corp., 2009b).

Environment

Because of the toxic nature of beryllium, various international, national, and State guidelines and regulations have been established regarding beryllium content in air, water, and other media. Industry must maintain careful control over the quantity of beryllium dust, fumes, and mists in the workplace. Control of potential health hazards adds to the final cost of beryllium products (Petkof, 1985, p. 80; Rossman, Preuss, and Powers, 1991, p. 277–281; Kramer, 1998, p. 107–108; Smith, Ingerman, and Amata, 2002, p. 11–15, 193–200).

Consumption

U.S. apparent consumption of all beryllium materials, as calculated from mine shipments, net trade, and changes in Government and industry stocks, was estimated to be about 167 t of contained beryllium in 2009, which was a decrease of 23% from the 218 t calculated for 2008. The decrease in apparent consumption was the result of reduced shipments of beryl ore, BCMA, and beryllium metal from the NDS, and the reduced production and consumption of bertrandite by Brush Wellman.

Since the closure of Brush Wellman's primary beryllium production facility in Elmore, OH, in 2000, the company has met its beryllium metal requirements by purchasing materials from the NDS and foreign producers. BEM's Beryllium and Beryllium Composites unit manufactured products of beryllium metal and two families of metal matrix composites—one made from aluminum and beryllium and the other made from beryllium and BeO. The products, in the form of foil, rods, sheets, tubes, and a variety of customized shapes, were produced at plants in Elmore and in Fremont, CA. Sales of beryllium products for defense applications, primarily aerospace and missile systems, and for medical and industrial x-ray applications decreased 26% compared with those of 2008, primarily owing to delayed funding for orders from the defense market in the second half of 2009. Development work on high-end beryllium speaker domes continued throughout 2009, with market growth expected in 2010 (Brush Engineered Materials Inc., 2010a, p. 32).

BEM's Beryllium and Beryllium Composites unit included Brush Ceramic Products Inc., which produced BeO ceramic products for aerospace, defense, electronics, medical, semiconductor, telecommunications, and wireless applications at its plant in Tucson, AZ. Sales of ceramic products decreased 42% in 2009 compared with those of 2008 as the worldwide economic downturn affected BEM's key ceramic customer (Brush Engineered Materials Inc., 2010a, p. 32).

BEM's Specialty Engineered Alloys unit produced copper- and nickel-based alloy products, the majority of which contained beryllium. Alloy strip products (which were used as connectors, contacts, shielding, switches, and relays) and alloy bulk products (including bar, plate, rod, tube, and customized forms) were produced at plants in Elmore and in Shoemakersville, PA. In 2009, the total shipment volume of alloy strip products was 32% lower than that of 2008—the result of continued softening in the automotive electronics market, the computer and telecommunications market, and excess inventories in the supply chain brought on by the global financial situation and related economic downturn. The total shipment volume of bulk alloy products decreased 45% compared with that of 2008—the result of reduced demand from the aerospace, oil and gas markets, and excess inventories within the supply chain (Brush Engineered Materials Inc., 2010a, p. 30, 31).

BEM's long-term supply arrangement with JSC Ulba Metallurgical Plant (UMP), which was part of Kazakhstan's National Atomic Company Kazatomprom JSC, and its marketing representative RWE NUKEM, Inc. (Danbury, CT) to purchase BCMA and beryllium vacuum-cast billet was terminated on December 31, 2008. In 2009, any purchases by BEM from RWE NUKEM used BEM's normal purchasing practices (Brush Engineered Materials Inc., 2010a, p. 76).

BEM announced that its Electrofusion Products group would provide four beryllium beam pipes for the Large Hadron Collider (LHC), a particle accelerator located near Geneva, Switzerland. The LHC planned to recreate the conditions just after the Big Bang event that theoretically led to the formation of the universe, using the beryllium beam pipes to ensure high energy collisions of subatomic particles. The beryllium in the beam pipes is essentially transparent to the subatomic particles owing to its low atomic number and low density, allowing the particle detectors to be free of significant interference. The beryllium in the beam pipes allows the pipes to remain dimensionally stable with the ultra high vacuum inside. Other advantages of using beryllium in the beam pipes include thermal stability at temperatures approaching absolute zero and lack of magnetism which allows multipole magnets to steer and focus the particle beam without interference. Beryllium's low atomic number also keeps the pipes from becoming radioactive from the radiation bombarding them (Brush Engineered Materials Inc., 2009).

In 2009, as part of IBC's effort to develop downstream beryllium manufacturing capabilities, the company entered into a letter of intent to acquire Beralcast Corp., a privately held specialty alloy manufacturing business based in Nashua, NH, which owned proprietary and patented technology for a castable beryllium aluminum alloy currently used in a variety of aerospace and advanced technology applications. IBC also acquired Specialloy Copper Alloys, LLC (New Madrid, MO), an established specialty alloy manufacturer. Specialloy had significant unused manufacturing capacity, which will be upgraded by IBC for beryllium-copper casting products. In 2008, IBC acquired Freedom Alloys Inc. (Royersford, PA), a primary producer-supplier of beryllium-copper casting and master alloy ingot products and Nonferrous Products Inc. (Franklin, IN), a specialty alloy processing company and manufacturer of forged copper, beryllium-copper, and bronze alloys (Dutton, 2009; IBC Advanced Alloys Corp., 2009a; International Beryllium Corp., 2009, p. 4).

In November, IBC signed a letter of intent with Kazatomprom agreeing to three specific initiatives. The first was to negotiate a 3-year agreement whereby Kazatomprom's UMP would supply beryllium and beryllium alloy to IBC on preagreed terms. The second was to explore mutually beneficial strategic partnerships. The third was to assess the feasibility of a Kazakhstan-based high-volume BeO production facility to support IBC's beryllium-enhanced nuclear fuel initiative (IBC Advanced Alloys Corp., 2009c).

In December, IBC signed a research proposal with a Washington, DC-based clean-energy consulting company to develop the commercial application of beryllium and BeO in the wind energy and turbine market. IBC and its research partner will assess the feasibility of an advanced plasma-based method of applying a BeO coating to beryllium, beryllium copper, and aluminum bronze. A BeO coating on bearings would increase the wear resistance in wind turbines and therefore increase reliability and reduce the costs of operation (IBC Advanced Alloys Corp., 2009d).

Other domestic producers of beryllium alloy products included Applied Materials Science, Inc., Concord, MA; NGK Metals Corp. (a subsidiary of NGK Insulators, Ltd.), Sweetwater, TN; and Olin Corp.'s Brass Division, East Alton, IL. American Beryllia Inc. produced beryllium oxide ceramic products at its plant in Haskell, NJ.

Recycling

Beryllium was recycled primarily from new scrap generated during the manufacture of beryllium-containing components. Detailed data on the quantities of recycled beryllium are not available but may represent as much as 10% of U.S. apparent consumption (Cunningham, 2004).

Foreign Trade

U.S. foreign trade in beryllium materials, as reported by the U.S. Census Bureau, is summarized in table 3. On the basis of estimated contained beryllium, beryllium exports decreased by 80% compared with those of 2008. Canada and Japan were the major recipients of these materials. On the basis of estimated contained beryllium, total beryllium imports decreased by 69% compared with those of 2008; however, beryllium ores and beryllium waste and scrap increased. Japan and Kazakhstan remained the leading suppliers of beryllium materials to the United States.

Net import reliance as a percentage of apparent consumption is used to measure the adequacy of current domestic beryllium production to meet U.S. demand. Net import reliance was defined as imports minus exports plus adjustments for Government and industry stock changes. Releases from stocks, including shipments from the NDS, were counted as part of import reliance, regardless of whether the materials were imported or produced in the United States. For 2009, net import reliance as a percentage of apparent consumption was estimated to be about 28% compared with about 20% in 2008. The increase was primarily the result of a decrease in U.S. beryllium mine shipments and continued drawdown in industry stock.

World Review

China.—Yingtan Ulba Shine Metal Materials Co. Ltd. (a joint venture between UMP and Ningbo Shengtai Electronic Metal Material Co. Ltd.) was formed in 2007 to increase UMP's presence in the Chinese high-tech market. UMP was to supply the raw materials, which would be processed into copper-beryllium mill products at Ningbo's plant in the Cixi Economic Development Zone of Ningbo, Zhejiang Province (Interfax Central Asia General Newswire, 2006; Interfax China Ltd., 2007). In 2009, Yingtan Ulba Shine completed construction of a plant and began production of flat-rolled products from high-strength, conductive beryllium-copper alloys. Plant capacity was reported to be about 2,000 metric tons per year (gross weight) for all products, and capacity utilization was expected to be 100% by yearend (Interfax Russia & CIS Metals and Mining Weekly, 2009; Kazakhstan International Business Magazine, 2009).

Kazakhstan.—Kazatomprom reported beryllium sales revenues to be 41% lower than those of 2008. UMP supplied about one-third of beryllium products to the world market in 2009, compared with 3% in 1999. UMP reportedly produced from stockpiled beryllium concentrate imported mainly from Russia. The stockpile, which was built up during the Soviet era, was forecast in 2003 to be sufficient to support production for about 30 years (Metal Bulletin, 2003; McNeil, 2006; Kazatomprom JSC, 2010, p. 31, 32). Kazatomprom signed a letter of intent with

Toshiba Corp. in 2009 to establish a joint venture for the research, exploration, production, and sales of rare metals, including beryllium. Previously, as part of Japan's efforts to reduce its dependence on crude oil from the Middle East, Toshiba made an agreement with Kazatomprom in 2008 to secure supplies of rare metals and reactor components for Toshiba's nuclear power business. The agreement expanded on an existing deal under which Kazatomprom supplied uranium for Toshiba-built nuclear plants (Soble and Gorst, 2008; Reuters, 2009).

Russia.—In 2009, it was announced that East Siberian Metals Corp. and UMP (Kazakhstan) signed a cooperative agreement to develop the Yermakovskoye beryllium deposit in the Siberian Republic of Buryatiya. Russian Technologies State Corp. was also interested in partnering on the project. Yermakovskoye was considered to be the largest beryllium deposit in Russia (Metal-Pages, 2008; Metropol Investment Financial Co. Ltd., 2009).

Outlook

The United States is expected to remain self-sufficient with respect to most of its beryllium requirements. At yearend 2009, BEM reported proven bertrandite reserves in Juab County of 5.83 million dry metric tons (6.43 million dry short tons) with an average grade of 0.266% beryllium. This represented about 15,500 t of contained beryllium. BEM owned approximately 95% of its proven mineral reserves and leased the remainder (Brush Engineered Materials Inc., 2010a, p. 42–43).

It was expected that the 2010 U.S. shipments of beryllium-copper strip products and beryllium bulk products would increase considerably from those of 2009 owing to improved market conditions. Increased demand for strip products was anticipated from the automotive electronics, and telecommunications and computer markets, with the telecommunications and computer markets' consumer electronics segment expected to increase substantially in 2010. Increased demand for bulk products was expected from the aerospace and oil and gas markets. Increased demand for beryllium-based metals and metal matrix composites was anticipated from defense and commercial applications, including medical and analytical x-ray product applications (Brush Engineered Materials Inc., 2010b).

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TABLE 1
SALIENT BERYLLIUM MINERAL STATISTICS

(Metric tons of beryllium content)

	2005	2006	2007	2008	2009
United States, beryllium-containing ores:					
Mine shipments[1]	110	155	150	175	120
Imports for consumption, beryl[2]	--	--	1	--	1
Consumption, reported[3]	160	180	190	220	150
Stocks, December 31:					
Industry[1]	35	50	100	60	30
U.S. Government, beryl[2, 4]	165	9	8	(5)	(5)
World, production[e, 2]	138	174	174	197	144

[e] Estimated. -- Zero.

[1] Data are rounded to the nearest 5 metric tons.

[2] Based on a beryllium content of 4%.

[3] Data are rounded to the nearest 10 metric tons.

[4] Defense National Stockpile Center. Data for 2005–06 include beryl committed for sale pending shipment and uncommitted beryl. Data for 2007–09 are uncommitted beryl only.

[5] Less than ½ unit.

TABLE 2
U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE BERYLLIUM STATISTICS IN 2009[1]

(Metric tons of beryllium content)

Material	Stockpile goal[2]	Disposal authority[3]	Annual Materials Plan[4]	Uncommitted inventory, December 31
Beryl ore	--	(5)	36 [6]	(5)
Beryllium-copper master alloy	--	--	11 [6]	--
Beryllium metal:				
Hot-pressed powder	45	87	--	132 [7]
Vacuum-cast	--	8	36	8
Total	45	95	36	141
Grand total	45	95	83	141

-- Zero.

[1] Data were converted from gross weights reported in short tons; may not add to totals shown.

[2] Goal effective as of December 28, 2001.

[3] Total quantity of material that can be disposed.

[4] Maximum quantity of material that can be disposed during 12-month period ending September 30, 2009.

[5] Less than ½ unit.

[6] Actual quantity will be limited to remaining inventory.

[7] Held for goal.

Source: Defense National Stockpile Center.

TABLE 3
U.S. FOREIGN TRADE OF BERYLLIUM MATERIALS, BY TYPE[1]

Type and material	2008 Gross weight (kilograms)	2008 Content[2] (kilograms)	2008 Value (thousands)	2009 Gross weight (kilograms)	2009 Content[2] (kilograms)	2009 Value (thousands)	Principal destinations or sources, 2009[3]
Exports:							
Beryllium, unwrought[4]	69,500	69,500	$4,100	5,840	5,840	$231	Japan, 69%; Switzerland, 18%; Germany, 4%; Republic of Korea, 4%; South Africa, 4%.
Beryllium waste and scrap	16,400	16,400	1,140	--	--	--	
Beryllium, other[5]	26,700	26,700	11,300	17,000	17,000	11,500	Canada, 55%; France, 15%; United Kingdom, 8%; Germany, 6%; Japan, 6%; Singapore, 2%.
Total	113,000	113,000	16,500	22,900	22,900	11,700	Canada, 41%; Japan, 22%; France, 11%; Germany, 6%; United Kingdom, 6%; Switzerland, 5%; Republic of Korea, 2%; Singapore, 2%.
Imports:							
Beryllium ores and concentrates	--	--	--	18,000	720	7	Uganda, 100%.
Beryllium oxide and hydroxide	1	(6)	2	--	--	--	
Beryllium, unwrought[4]	33,200	33,200	2,440	2	2	3	Kazakhstan, 100%.
Beryllium waste and scrap	4,730	4,730	790	6,700	6,700	161	Germany, 98%; France, 2%.
Beryllium, other[5]	5,840	5,840	996	5,660	5,660	833	Kazakhstan, 52%; Japan, 28%; Republic of Korea, 12%; Canada, 7%.
Beryllium-copper master alloy	663,000	26,500	9,270	205,000	8,220	2,800	Kazakhstan, 55%; Japan, 40%; Germany 4%.
Beryllium-copper plates, sheets, and strip	485,000	7,270	7,000	165,000	2,480	1,920	Japan, 99%.
Total	1,192,000	77,600	20,500	401,000	23,800	5,720	Japan, 31%; Kazakhstan, 31%; Germany, 29%; Republic of Korea, 3%; Uganda, 3%; Canada, 2%.

XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Estimated from gross weights.

[3] Principal destinations or sources percentages based on estimated beryllium content.

[4] Includes powders.

[5] Includes articles not elsewhere specified.

[6] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4
BERYL: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country[3]	2005	2006	2007	2008	2009[e]
China[e]	500	500	500	500	500
Madagascar[e, 4]	12	12	12	12	12
Mozambique	146	16	31 [r]	8 [r]	45
Portugal[e]	5	5	5	5	5
United States, mine shipments[5]	2,780	3,830	3,810	4,410	3,030
Total	3,450	4,360	4,360	4,940 [r]	3,590

[e] Estimated. [r] Revised.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 10, 2010. Unless otherwise noted, figures represent beryl ore for the production of beryllium and exclude gem-quality beryl.

[3] Argentina, Kazakhstan, Nigeria, Russia, and Uganda may have produced beryl ore, but information is inadequate to make reliable estimates of production. Other nations that produced gemstone beryl ore may also have produced some industrial beryl ore.

[4] Includes ornamental and industrial products.

[5] Includes bertrandite ore, calculated as equivalent to beryl containing 11% beryllium oxide.

BISMUTH

By James F. Carlin, Jr.

Domestic survey data and tables were prepared by Lisa Mersdorf, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

Bismuth consumption in the United States was estimated to be 1,180 metric tons (t), an increase of 8% compared with that of 2008 (tables 1, 2). The estimated value of bismuth consumed domestically was $19 million in 2009. The estimated domestic consumption breakdown for bismuth for 2009 was: 60% for chemical and pharmaceutical uses; 36% for metallurgical additives for casting and galvanizing; and 4% for bismuth alloys, fusible alloys, solder and ammunition (table 2).

Bismuth was last produced domestically, as a byproduct of lead refining, at a Nebraska refinery that closed in 1997. The last stocks of bismuth in the National Defense Stockpile were sold that same year. In 2009, all primary bismuth consumed in the United States was imported. Only a small amount of bismuth was obtained by recycling old scrap. The leading producers of refined bismuth in 2009 were, in descending order, China, Mexico, Belgium, and Peru. Belgium had no bismuth mine production, and its sole bismuth producer refined metal from anode slimes, concentrates, and smelter residues and flue dust, all of foreign origin. The principal suppliers to the United States were China, Belgium, the Republic of Korea, the United Kingdom, and Mexico, in descending order.

In recent years, new uses for bismuth as a nontoxic substitute for lead have been developed. These include the use of bismuth in shot for water fowl hunting, lubricating greases, pigments, and solders.

The annual average dealer price for bismuth in 2009 decreased to $7.84 per pound, a 38% decrease from that of 2008. Industry observers attributed the price decline to the world economic slowdown.

Production

Domestic production of primary refined bismuth ceased in 1997. Some domestic firms continued to recover secondary bismuth from fusible alloy scrap in 2009, but secondary production data were not available. Secondary production was estimated to be less than 5% of domestic supply during the year.

Consumption

The U.S. Geological Survey surveys domestic bismuth consumption annually. The amount used by nonrespondents is estimated based on reports from prior years or on information from other sources. Accordingly, estimated bismuth consumption was about 1,180 t in 2009, an increase of 8% compared with that of 2008.

Consumption of bismuth in chemical uses (chemicals, cosmetics, and pharmaceuticals) in 2009 increased by 18% compared with that in 2008. The alloys category of use registered a 31% decline in consumption in 2009 compared with that in 2008. Metallurgical additives experienced a 13% increase in consumption in 2009 compared with those in 2008. These substantial declines, especially for alloys and metallurgical additives, were attributed to the general economic slowdown, which especially affected industrial applications.

Bismuth pharmaceuticals include the well-known bismuth salicylate (the active ingredient in over-the-counter stomach remedies) and other bismuth medicinal compounds used to treat burns, intestinal disorders, and stomach ulcers in humans and animals. Bismuth nitrate is the initial material used for the production of most bismuth pharmaceutical compounds. Other applications of bismuth chemicals and compounds include uses in superconductors and pearlescent pigments for cosmetics and paints.

Bismuth metal is used primarily as a major constituent of various alloys and as a metallurgical additive (table 2). One class of bismuth alloys consists of fusible (low-melting-point, as low as 20° C) alloys, which are combinations of bismuth with other metals, such as antimony, cadmium, gallium, indium, lead, and tin. Applications for those alloys include fuel tank safety plugs, holders for optical lens grinding, and other articles for machining or grinding, solders, and fire sprinkler triggering mechanisms.

In addition to lead-free solder noted above, bismuth has been a substitute for lead added to certain steel products to provide greater machinability. A major domestic steel producer began to use a bismuth-containing substitute for the leaded alloy about 1982. Although bismuth has been used successfully to replace lead in various applications, it has been challenged as a lead substitute by tin and tungsten (Cusack, 1999).

Bismuth is also added in small amounts to aluminum (along with lead) and copper alloys to improve machinability. It is also added to malleable iron graphite flakes. These uses constitute the traditional metallurgical additives category.

Prices

In 2009, the annual average Platts Metals Week New York dealer price for bismuth declined to $7.84 per pound, a decrease of 38% from that in 2008. The annual average price had experienced a steady and substantial rise from 2003 to 2007.

In 2009, the weekly bismuth price started the year at $8.50 to $9.50 per pound. The price reached a low for the year in early August, at $5.50 to $6.50 per pound, then rose later in the third and fourth quarters to finish the year at $7.35 to $8.00 per pound.

Foreign Trade

U.S. exports of bismuth metal, alloys, and waste and scrap rose by 6% compared with those in 2008. Notable increases were recorded for exports to Belgium, China, France, and

Vietnam. Substantial decreases were noted for exports to Canada, Mexico, Thailand, and the United Kingdom.

U.S. imports of metallic bismuth decreased by 35% compared with the 2008 figures (table 4). Bismuth imports were about three times greater (by weight) than bismuth exports. The leading import source for the United States was China, which supplied 44% of imports. Considerable increases in imports were observed for those from the Republic of Korea and Mexico. There were sizable decreases in imports from China, Hong Kong, Peru, and the United Kingdom.

World Review

In much of the world, bismuth is produced as a byproduct of smelting lead ores. In China, it is also a byproduct of fluorspar, tin, and tungsten ore processing. In Bolivia, the Tasna Mine, the only mine that produces bismuth from bismuth ore, has been on standby since the mid-1990s, awaiting a sufficient and substantial rise in the metal price.

World refinery production of bismuth was 15,000 t, the same as that in 2008. China was the world's leading producer of refined bismuth with 80% of the world total, followed by Mexico with 6%, and Belgium with 5%.

Bolivia.—The Mining and Metallurgy Ministry announced that exports of bismuth from the Telamayo smelter in Potosi Department would begin in June 2009. The smelter, which was restarted in late 2008 following an investment of $1 million, refined minerals, such as antimony, arsenic, bismuth, copper, tin, and tungsten. Telamayo produced 1 metric ton per day of bismuth, which was a byproduct of refined copper, lead, and tin production (Metal-Pages, 2009).

Canada.—Fortune Minerals Ltd. (London, Ontario) announced further progress with its NICO gold-cobalt-bismuth-copper project. NICO is a planned vertically integrated project to mine and concentrate ores from Fortune's deposit in the Northwest Territories. Fortune entered into an agreement to purchase land near Saskatoon, Saskatchewan, on which it proposes to construct its southern hydrometallurgical facility. Bulk concentrates would be transported by truck and rail to the facility for processing to high-value metal products, including bismuth cathodes, cobalt, copper, and gold dore. Beginning in 2012, the Saskatoon refinery would process 80,000 metric tons per year (t/yr) of NICO sulfide concentrates each year, yielding average production of 1,800 t/yr of 99.8% cobalt cathode, 1,900 t/yr of 99.8% bismuth cathode, as well as 2,500 kilograms per year (kg/yr) of gold in the first 2 years of mine life, followed by 840 kg/yr of gold production in subsequent years (Fortune Minerals Ltd., 2009).

Mexico.—Met-Mex Penoles S.A. de C.V. (Torreon), a significant bismuth refiner, declared force majeure on its lead and precious metals processing in March owing to a strike that began in February over a wage dispute. Because of an oversupplied world bismuth market, the force majeure did not materially affect prices. The 60-day strike ended in April (Metal Bulletin, 2009).

Peru.—Doe Run Peru (Lima) encountered financial difficulties and furloughed its workers from August 1 through yearend (American Metal Market, 2009). Doe Run Peru announced that it had signed a letter of intent with Glencore International AG (Baar, Switzerland) for a credit line that could be used as working capital to restart its La Oroya polymetallic smelter, which has been idle since June 2009. The funds also could be partially used to finance part of its environmental cleanup program at La Oroya, which was estimated to cost $156 million. La Oroya refined bismuth as well as several other metals (American Metal Market, 2010).

Outlook

Over much of the past decade, worldwide bismuth demand has been increasing at about 3% to 5% per year. However, the global economic slowdown that began in late 2008 and extended through 2009 led to a substantial contraction in consumption. World consumption of bismuth in the steel sector decreased, although it was relatively minor compared with that in other use sectors. World consumption in the chemical industry seemed to be rising, especially in Japan, as bismuth began to replace lead in pigments.

Selected segments of the bismuth use markets, such as metallurgical additives in particular, were very much involved in the industrial sectors of the economy, and any improvement there will likely depend on how quickly the world's industrialized nations can rebound from the 2008–09 economic slowdown.

Commercial and research organizations in Europe, Japan, and North America agreed to a framework to eliminate lead from solders in manufacturing. This agreement would tend to increase the demand for bismuth during the 2010 through 2012 period because bismuth is used in some solders. Many Japanese manufacturers were using lead-free solders in some or all of their soldering applications, and studies on how best to develop lead-free solders were being performed independently by the European Union, Japan, the Republic of Korea, and the United States. Although world lead consumption was expected to be reduced by only 0.8% by these moves, world bismuth consumption may increase by about 25% by this trend.

A significant, near-term increase in supplies of lead byproduct bismuth was unlikely because world production of lead from mine sources was expected to be relatively stable, and an increasing portion of lead demand was expected to be met by recycling. A global shortage of bismuth, however, was not anticipated. In China, new technologies have increased world bismuth reserves. Therefore, despite large increases in world demand, supplies from China can be expected to help keep the bismuth market stable.

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TABLE 1

SALIENT BISMUTH STATISTICS[1]

		2005	2006	2007	2008	2009
United States:						
Consumption[e, 2]	metric tons	2,390	1,960	2,630	1,090	1,180
Exports[3]	do.	142	311	421	375	397
Imports for consumption	do.	2,530	2,300	3,070	1,930	1,250
Price, average, domestic dealer	dollars per pound	3.91	5.04	14.07	12.73	7.84
Stocks, December 31, consumer	metric tons	175	120 [r]	139 [r]	228	134
World production:[e, 4]						
Mine, metal content[5]	do.	5,400	5,800	6,200	7,600 [r]	8,200
Refinery	do.	14,000	15,000	16,000	15,000	15,000

[e] Estimated. [r] Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits.

[2] Estimated based on net imports.

[3] Comprises bismuth metal and the bismuth content of alloys and waste and scrap.

[4] Data are rounded to no more than two significant digits.

[5] Excludes the United States.

TABLE 2

ESTIMATED BISMUTH METAL CONSUMED IN THE UNITED STATES, BY USE[1, 2]

(Metric tons)

Use	2008	2009
Chemicals[3]	597	706
Bismuth alloys	75	52
Metallurgical additives	375	422
Other	38	3
Total	1,090	1,180

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Estimated based on net imports.

[3] Includes industrial and laboratory chemicals, cosmetics, and pharmaceuticals.

TABLE 3
U.S. EXPORTS OF BISMUTH METAL, ALLOYS, AND WASTE AND SCRAP, BY COUNTRY[1]

Country	2008		2009	
	Quantity (kilograms, metal content)	Value (thousands)	Quantity (kilograms, metal content)	Value (thousands)
Argentina	8,340	$78	220	$17
Australia	319	3	--	--
Austria	140	4	--	--
Belgium	--	--	56,600	820
Belize	21	3	--	--
Bolivia	--	--	136	3
Brazil	28,400	264	13,400	121
Canada	55,100	866	32,900	701
China	3,210	79	28,800	261
Colombia	3,120	82	1,230	29
Costa Rica	2,130	19	--	--
Cyprus	51	7	34	4
Czech Republic	3,400	31	99	9
Dominican Republic	8,950	81	6,550	60
Egypt	1,020	38	97	6
France	13,600	791	121,000	1,450
Germany	3,380	39	2,420	37
Hong Kong	1,730	30	2,410	26
India	770	14	121	3
Ireland	124	4	--	--
Israel	3,490	33	--	--
Japan	4,460	117	11,000	309
Korea, Republic of	54	5	--	--
Mexico	76,400	998	59,300	1,350
Paraguay	--	--	106	4
Saudi Arabia	1,470	13	27	3
Singapore	8,680	103	445	30
Slovenia	--	--	316	3
South Africa	50	7	30	3
Spain	163	9	283	3
Sweden	794	12	83	7
Taiwan	55	9	219	16
Thailand	25,500	446	8,590	78
Turkey	--	--	361	11
United Arab Emirates	20	4	--	--
United Kingdom	101,000	2,370	4,710	50
Vietnam	18,400	174	45,200	411
Total	375,000	6,730	397,000	5,820

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 4

U.S. IMPORTS FOR CONSUMPTION OF METALLIC BISMUTH, BY COUNTRY[1]

	2008		2009	
Country	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Belgium	509,000	$10,500	450,000	$8,350
Canada	18,500	229	5,740	88
China	998,000	24,200	554,000	8,180
France	23,100	533	--	--
Germany	696	41	1,600	94
Hong Kong	93,500	1,980	--	--
Italy	50	7	50	8
Japan	104	15	--	--
Kazakhstan	--	--	9,850	185
Korea, Republic of	--	--	75,100	1,170
Mexico	40,000	1,080	59,400	758
Netherlands	416	91	124	22
Peru	55,700	1,100	29,400	386
Poland	80	17	--	--
Russia	--	--	3,320	239
Spain	825	29	--	--
Switzerland	6	5	--	--
United Kingdom	186,000	4,890	62,400	1,110
Total	1,930,000	44,700	1,250,000	20,600

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 5

BISMUTH: ESTIMATED WORLD MINE AND REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

	Mine					Refinery				
Country	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009
Belgium	--	--	--	--	--	800	800	800	800	800
Bolivia	44 [3]	155 [r, 3]	147 [3]	28 [r, 3]	50	-- [3]	1 [r, 3]	-- [3]	92 [r, p]	100
Bulgaria	40	45	45	45	NA	35 [3]	30	30	30	NA
Canada[4]	185	177 [r, 3]	137 [3]	71	86 [3]	250	250	200	150 [r]	150
China	3,000	3,000	3,500	5,000	6,000	10,600	11,800	12,100	12,000	12,000
Italy	--	--	--	--	--	5	5	5	5	5
Japan[5]	23	21	20	20	21	463 [3]	425 [3]	408	410 [r]	420
Kazakhstan	140	140	145	150	150	120	115	120	125	125
Mexico	970 [3]	1,186 [3]	1,200	1,170	854	970 [3]	1,186 [3]	1,200	1,170	854
Peru	952 [3]	950	950	960	960 [p]	600	600	600	600	600
Romania	40	40	40	40	40	35	30	30	30	NA
Russia	50	55	55	70	65	10	11	12	13	12
Total[6]	5,400	5,800	6,200	7,600 [r]	8,200	14,000	15,000	16,000	15,000	15,000

[p] Preliminary. [r] Revised. NA Not available. -- Zero.

[1] Estimated data are rounded to no more than three significant digits.

[2] Table includes data available through April 1, 2010. Bismuth is produced primarily as a byproduct of other metals, mainly lead and tungsten.

[3] Reported figure.

[4] Figures listed under mine output are the metal content of concentrates produced, according to Natural Resources Canada, 2005–06.

[5] Mine output figures have been estimated to be 5% of reported metal output figures.

[6] World totals are rounded to no more than two significant digits.

BORON

By Marc A. Angulo

Domestic survey data and tables were prepared by Forest H. Morgan, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

U.S. consumption of minerals and compounds reported in boron oxide continued to increase in 2009 but has been withheld to avoid disclosing company proprietary data (table 1). Turkey and the United States were the world's leading producers of boron minerals (table 6). World production of boron minerals decreased in 2009 to an estimated 3.51 million metric tons (Mt) compared with 3.85 Mt in 2008 (excluding U.S. production). The amount of boron compounds exported in 2009 was 171,000 metric tons (t) of boric acid and 417,000 t of sodium borate (tables 1, 4). Boron imports consisted primarily of borax, boric acid, colemanite, and ulexite (tables 1, 5).

Elemental boron is a metalloid which has limited commercial applications. Boron compounds, chiefly borates, are commercially important; therefore, boron products are priced and sold based on boric oxide content (B_2O_3), which varies by ore and compound, and on the absence or presence of sodium and calcium (table 2). Borax, one of the most important boron minerals for industrial use, is a white crystalline substance chemically known as sodium tetraborate decahydrate and found in nature as the mineral tincal. Boric acid, also known as orthoboric acid or boracic acid, is a white, colorless crystalline solid sold in technical, national formulary, and special quality grades as granules or powder. Colemanite (hydrated calcium borate), kernite (hydrated sodium borate), tincal, and ulexite (hydrated sodium calcium borate) were the minerals of most commercial importance in the United States (table 2).

Production

Four minerals make up 90% of the borates used by industry worldwide: the sodium borates tincal and kernite, the calcium borate colemanite, and the sodium-calcium borate ulexite. Borate deposits are associated with volcanic activity and arid climates, with the largest borate deposits located in the Mojave Desert of the United States, the Alpide belt in southern Asia, and the Andean belt of South America. As a result, most borates were extracted primarily in California and Turkey and to a lesser extent in Argentina, Bolivia, Chile, China, and Peru. Boron compounds and minerals were produced by surface and underground mining and from brine.

Domestic data for boron were derived by the U.S. Geological Survey from a voluntary survey of two U.S. producers—Rio Tinto Group's U.S. Borax Inc. and Searles Valley Minerals, Inc. (SVM). Both companies responded; however, data were withheld to avoid disclosing company proprietary data (table 1).

The calcium borate mine in Newberry Springs, CA, owned and operated by Fort Cady Minerals Corp., has been idle since February 2003. The Billie Mine, the last active mining operation in Death Valley National Park, CA (owned by American Borate Co.), closed in 2008 (National Park Service, 2010). American Borate continued to import Turkish ulexite and colemanite, which was processed in plants in Chesapeake, VA, and Blacksburg, SC, through Industrial Minerals Inc. (American Borate Co., 2005; Industrial Minerals Inc., 2007).

SVM produced borax and boric acid from brines containing potassium and sodium borates which were extracted from three salt layers, up to 100 meters (m) deep, in Searles Lake, located near Trona in San Bernardino County, CA. SVM's Trona and Westend plants refined the brines, producing anhydrous, decahydrate, and pentahydrous borax. These brines also supplied other commercial salts in addition to sodium borates and boric acid.

Rio Tinto Borax (a wholly owned subsidiary of United Kingdom-based Rio Tinto Minerals) mined mainly tincal and kernite at Boron, CA, by open pit methods, and the ore was transported by truck to a storage area. Boric acid and refined sodium borates were produced at an onsite processing plant. Refined borate products were shipped by railcar or truck to North American customers or to the company's Wilmington facility at the Port of Los Angeles for international distribution. Specialty borate products were made at the Wilmington plant. According to a Securities and Exchange Commission report filed by Rio Tinto Borax, the company produced 411,000 t of borates in 2009, a 30% decrease from the 591,000 t reported in 2008 (Rio Tinto plc, 2010, p. 26). As part of a divestment program in September 2007, Rio Tinto Minerals put Rio Tinto Borax on sale. In July 2009, the company canceled the sale because bidders had not matched the valuation of the asset (Industrial Minerals, 2009d).

Consumption

The first reported use of borax was as a flux or bonding agent by Arabian gold and silversmiths in the eighth century, but current research suggests Babylonians may have used it 4,000 years ago. Today, there are more than 300 end uses for borates, but more than three-quarters of the world's supply is sold and distributed to five end uses. The distribution of borates by end use in 2009 was glass, 57%; ceramics, 12%; fertilizer, 12%; detergent, 5%; and other, 14% (Garrett, 1998; Hamilton, 2006; Eti Maden AS, 2009, p. 19). Global demand for borates fell from 1.88 Mt of B_2O_3 in 2008 to 1.50 Mt of B_2O_3 in 2009, a 20% decrease, spurred by decreased Asian and European demand (Katsiouleris, 2010, p. 4).

In 2009, U.S. imports for consumption of borax, boric acid, colemanite, and ulexite were 96,000 t, which was 38% less than the 156,000 t imported in 2008. In 2009, total U.S. apparent consumption of all boron products increased by 15% compared with that of 2008.

Agriculture.—Boron was the most widely used micronutrient, applied primarily to promote seed production. Boron fertilizers were mostly sourced from borax and colemanite owing to their high water solubility; thus, boron fertilizers can be delivered through sprays or irrigation water. Total global demand for micronutrients was nearly 750,000 t in 2009 (Russell, 2010). Domestic consumption of boron fertilizers was estimated to be approximately 2% of total U.S. fertilizer consumption.

Boron is essential for plant uptake of primary and secondary nutrients, such as calcium, manganese, magnesium, phosphorus, and zinc. It influences the transport of nutrients through plant membranes, which directly correlates into improved fruit development, germination, plant reproduction, and pollen production. Normal plant leaves typically contain 25 to 100 parts per million of boron, with 1 kilogram per hectare of boron (1 pound per acre) in soil being adequate to maintain these levels. U.S. boron deficiencies in crops are found primarily in the Atlantic coastal plains, Great Lakes region, and the coastal Pacific Northwest, where soils tend to be acidic, leached, coarse sandy, or organic in nature. Excessive boron fertilization, on the other hand, can cause crop toxicity, which studies suggested was more often caused by higher boron levels in irrigation water than those in soil (Troeh and Thompson, 2005, p. 489).

Ceramics.—Ceramics comprise the second largest application of borates after glass. Borates play an important role in ceramic glazes and enamels, increasing chemical, thermal, and wear resistance. Borax and colemanite are used in ceramics primarily as fluxing agents, with borax being used in higher temperature, and colemanite in lower temperature firings. Borates are also used in technical ceramics, an industry with applications in aerospace, ballistics, electronics, and medicine, which observed strong growth during the past decade.

Boron carbide is a key ingredient in lightweight ceramic armor, the use of which created increased United States and European consumption of boron carbide during the past few years. Small Arms Protective Inserts, used by the U.S. military, are boron carbide ceramic plates inserted into Kevlar flak jackets to protect against high-velocity projectiles (Industrial Minerals, 2008b).

A new calcined borate, known as E4972, was developed to replace conventional frits used in ceramic glazes. Frits were incorporated into glazes to obtain the appropriate technical and aesthetic properties under short firing of ceramics. E4972 possesses a low solubility, which enables its use in glaze formation (Industrial Minerals, 2009a).

Detergents and Soaps.—Borates were used as oxygen-based bleaching agents, enzyme stabilizers, alkaline buffers, and water softeners in detergents and soaps. Two borates, sodium perborate and perborate tetrahydrate, were used as oxidizing bleaching agents since they contain true peroxygen bonds. Hydrogen peroxide, a very effective bleaching agent, is produced when sodium perborate undergoes hydrolysis when in contact with water. Because hydrogen peroxide cannot be effectively incorporated into detergents, sodium perborate acts as its carrier (Rio Tinto Borax, 2005). Sodium perborate, however, requires hot water to undergo hydrolysis, and concerns have emerged over excessive boron levels in waterways owing to sodium perborate in detergents. Sodium percarbonate has been used as a substitute primarily in Europe because it produces hydrogen peroxide at lower temperatures. This substitution has affected boron consumption considerably.

Ferroboron.—Ferroboron (FeB) is a binary alloy of iron with a boron content between 17.5% and 24% and is the lowest cost boron additive for steel and other ferrous metals. On average, the steel industry consumes more than 50% of the ferroboron produced annually (Eti Holding Inc., 2003). Boron steel, containing nearly 0.008% ferroboron, possesses a higher strength and lighter weight than that of average high-strength steel, and is a useful material in the manufacturing of safe and fuel efficient automobiles.

Ferroboron was also utilized in aluminum castings to refine grain; in copper-base alloys and high-conductance copper as a degasifier; and in the nonferrous metals industry, generally as a deoxidizer. Applications also include the manufacturing of neodymium-iron-boron (Nd-Fe-B) magnets, consuming nearly 10% of the ferroboron produced annually (Eti Holding Inc., 2003). Nd-Fe-B magnets possess the highest strength of all magnets and were used in computer hard drives, guidance systems, and wind turbines (Moores, 2010).

Fire Retardants.—Boric acid was incorporated into wood flame-retardants to inhibit the transfer of combustible vapors and reduce the effective heat of combustion, resulting in reduced flame spread. Zinc borate was used in plastics as a multifunctional boron-based fire retardant, with applications in a variety of plastics and rubber compounds. Zinc borate is mainly used in flexible and rigid polyvinyl chloride formulations partly substituting for antimony trioxide. It is increasingly used as a component of halogenated and halogen-free formulations in epoxies, nylons, polyolefins, rubber, and thermoplastic polyesters.

Glass.—Boron is used as an additive in glass to reduce thermal expansion, improve strength, chemical resistance and durability, and provide resistance against vibration, high temperature, and thermal shock. Boron is also used as a fluxing agent, reducing the viscosity of glass during formation to improve manufacturing. Depending on the application and quality of the glass, borax, boric acid, colemanite, ulexite, and sodium borates are typically used.

As in previous years, the glass industry remained the leading domestic market for boron. Insulation and textile fiberglass represents the largest single use of borates worldwide. Demand for fiberglass was dominated by the construction industry, which saw decreased U.S. activity in 2009 owing to the economic downturn. End uses for fiberglass are corrosion-resistant, heat-resistant, and high-strength fabrics, insulation, reinforcement, and sound absorption. The incorporation of borates into fiberglass greatly improves quality, establishing a product that is strong, lightweight, and thermal and chemical resistant (Garrett, 1998).

Borosilicate refers to glass with boric oxide content between 5% and 30%. The boron in borosilicate imparts many valuable properties to the glass, such as increased mechanical strength, low coefficient of thermal expansion, and resistance to chemical attack and thermal shock. Past application of borosilicate ranged from Pyrex® kitchenware to the thermal protection tiles on the National Aeronautics and Space Administration Space Shuttle Orbiter.

Other.—Borate treated wood is used in the construction of homes to protect against wood destroying organisms. Borates prevent fungal decay and are deadly to carpenter ants, roaches, and termites. Borate treated wood has been used successfully for more than 50 years in New Zealand and for a decade in Hawaii—specifically to combat highly destructive termites.

Boron fiber is a monofilament nearly 125 to 140 nanometers in diameter comprising elemental boron, typically produced under chemical vapor deposition of boron trichloride with tungsten wire acting as the catalyst. Owing to its high strength and hardness, boron fiber was used in the construction of the horizontal and vertical stabilizers and rudders of the F–14 and F-15 fighter and B–1 bomber aircrafts. The lower production cost and the higher availability associated with carbon fiber has limited boron fiber's use in modern aviation structural components. However, boron fiber has proven to be more advantageous than carbon fibers when used as a repair material for structural defects (Baker and others, 2004, p. 249).

Various boron compounds are used in nuclear powerplants to control neutrons produced during nuclear fission. The isotope boron-10, in particular, possesses a high propensity for absorbing free neutrons, producing molecules of lithium and alpha particles after absorbing neutrons. Control rods composed of boron carbide are lowered into a nuclear reactor to control the fission reaction by capturing neutrons. Boric acid is used in the cooling water surrounding nuclear reactors to absorb escaping neutrons (Ceradyne Inc., 2011).

Borazine and polyborazylene can be used as precursor chemicals to boron nitride coatings and composites. Boron nitride can also be found in large quantities in cosmetics owing to its low coefficient of friction and lack of toxicity. It has been shown to be an useful alternative to talcum powder, which studies show may be linked to ovarian cancer (Emsley, 2004, p. 15–17). Boric acid has applications in cosmetics, pharmaceuticals, and toiletries. Borates are also added to brake fluids, fuel additives, lubricants, metalworking fluids, and water treatment chemicals. Boron oxide inhibits corrosion.

Transportation and Distribution

Almost all U.S. borates were shipped in North America by rail. Both U.S. producers had rail fleets dedicated to the exclusive transportation of their products. Small shipments of borates were shipped by rail or truck in specialty bags, usually of 2,100-pound capacity. Prices for rail haulage depended on the ability of customers to load and unload efficiently, the ability to use unit trains and to supply one's own railcars, and fuel prices.

SVM owned the Trona Railway, a 50-kilometer (km) (31-mile) shortline railroad that connects to the Southern Pacific Railroad between Trona and Searles stations in California. The Trona Railway provided a dedicated line with access to the national rail system for the borate, soda ash, and sodium sulfate markets.

The Boron Mine (owned by Rio Tinto Borax) at Boron, CA, was served solely by the Burlington Northern Santa Fe Railroad. In order to connect to another rail line, a transload or transfer point was set up in Cantil, CA, served by the Union Pacific Railroad. Trucks of product from Boron were driven to Cantil, about 64 km (40 miles) northwest of Boron and loaded into dedicated railcars to be shipped to customers.

Rio Tinto Borax utilized a privately owned berth located in the Port of Wilmington, CA, for ocean transportation of borate products. Products destined for Europe were shipped from the bulk terminal in Wilmington to a company-owned facility in the Port of Rotterdam, Netherlands, company facilities in Spain, or contracted warehouses. The most centrally located Rio Tinto Borax port location in Europe was Antwerp, Belgium. The industrial minerals market in Europe was characterized by high volumes of imported materials, mostly forwarded through the industrialized areas of Belgium, France, Germany, and the Netherlands for destinations in Central Europe, including Austria, the Czech Republic, and Slovenia. A decision to import borates was based on the geographic location, the range of borate products needed, and prices.

Rio Tinto Borax used barges to ship borates from Rotterdam to customers in Belgium, Eastern Europe, France, and Germany. Barges were the most efficient and reliable mode of transportation throughout Europe because waterways provide an ideal, low-cost linkage between large industrial areas and the Baltic, Black, Mediterranean, and North Seas and the Atlantic Ocean.

Imports from South America and Turkey entered the United States principally through the ports of Norfolk, VA, and Philadelphia, PA.

Prices

Yearend prices of boron minerals and compounds produced in the United States are listed in table 3. Prices for borates have decreased from 2008 to 2009, reflective of an imbalance between supply and demand created by the economic downturn observed in the fourth quarter of 2008. Table 4 lists the free alongside ship values for U.S exports of boric acid and quantities of boric acid and refined sodium borate compounds exported to various countries. In 2009, China received the largest amount of sodium borates from the United States owing to increased consumption of borates used in the Chinese glass and ceramic industries.

World Review

Argentina.—Argentina remained the leading producer of boron minerals in South America in 2009 (table 6). Borate deposits are located primarily in the Puna region, which includes the northwestern tip of Argentina, the southeastern corner of Peru, the southwestern corner of Bolivia, and the northeastern edge of Chile. Recent increased demand in Asia and North America for borate use in ceramics and glass led to increased production of Argentine borates, boric acid in particular.

Borax Argentina S.A. (a subsidiary of Rio Tinto Minerals), the country's leading producer of borates, operated open pit mines at Porvenir in Jujuy Province and at Sijes and Tincalayu in Salta Province. These operations produced colemanite, hydroborocite, kernite, tincal, and ulexite at a rate of 100,000 metric tons per year (t/yr) (Industrial Minerals, 2009c). Located at 4,100 m (13,400 feet) above sea level, the Tincalayu Mine was Argentina's largest open pit operation. The deposit consisted primarily of borax, with rare occurrences of ulexite and 15 other borates. Rio Tinto also produced refined borate ores and boric acid at refineries in Campo Quijano, Sijes, and Tincalayu in Salta Province and Porvenir in Jujuy Province. Lithium

Americas Corp. entered into an agreement with Borax Argentina to extract subsurface lithium and borate brines from the salt lake at Jujuy Province. The company contends that the brine has the correct composition to be economically viable (Industrial Minerals, 2009f).

Minera Santa Rita S.R.L. (MSR) operated mines in Catamarca, Jujuy, and Salta Provinces and operated a processing plant in Campo Quijano, which produced granular deca- and pentahydrate borax, technical-grade boric acid powder, and various grades and sizes of the natural boron minerals. MSR refined more than 50,000 t/yr of borates and was expected to refine 75,000 t/yr after the investment in a flow bed system, a device that more efficiently dries boric acid. MSR has also announced a permanent supply agreement with Sulphaar S.R.L. to furnish sulphuric acid for the Campo Quijano plant (Santa Rita Mining Co., 2010).

Bolivia.—The most important Bolivian borate deposits, mined primarily by small cooperatives, are located in the Altiplano of the Andes and contain ulexite with associated tincal. The Bolivian mining agency, Corporación Minera de Bolivia (COMIBOL), was seeking to develop the Salar de Uyuni salt flats for future borate production. COMIBOL planned to establish a $5 million borate pilot plant on the deposit to determine full-scale feasibility. A full-scale boric acid plant was expected to produce 20,000 t/yr (Industrial Minerals, 2006, 2009c; Moores, 2009).

Chile.—In 2009, Chile was the second leading producer of boron minerals in South America (table 6). The Chilean borate producers were all located in the northeastern edge of Chile, which contains one the world's largest deposits of ulexite. The largest producer, Quimica e Industrial del Borax Limitada (Quiborax), mined 450,000 t/yr of crude ulexite and produced up to 80,000 t/yr of boric acid and 40,000 t/yr of granular ulexite (Tran, 2008).

China.—China possessed more than 100 borate deposits in 14 Provinces. The northeastern Province of Liaoning and the western Province of Qinghai accounted for more than 80% of the resources, mostly in the form of sassolite and tincal. Chinese boron resources are of low quality, averaging nearly 8.4% B_2O_3, in comparison to the Turkish and United States reserves, which average nearly 26% to 31% and 25.3% to 31.9% B_2O_3, respectively. Apparent consumption of borate in China increased by 7% per year between 2000 and 2009 fueled by the glass and ceramic industries, but domestic production remained relatively consistent during this period. To maintain this high level of consumption and moderate level of production, China became more import reliant on borate products originating from Russia, South America, the United States, and Turkey (Industrial Minerals, 2008a; Baylis, 2010, p. 5).

India.—India relied entirely on American, Chinese, and Turkish imports of borates to fulfill domestic needs. Borate products produced in India include boric acid, boron carbide, ferroboron, and sodium perborate. The leading producer of refined borates was Indo Borax & Chemical Ltd., which operated borax and boric acid plants in Pithampur, Madhya Pradesh, northeast of Mumbai.

Italy.—The Italian ceramic industry, which constitutes nearly 20% of global ceramics exports by volume, experienced its worst year owing to the global economic downturn. The industry observed a decline of 30% in output, 19.4% in sales volumes, and 19.6% in exports. Exports to the United States and Russia decreased by 39% and 46%, respectively. These declines created a drop in demand for many key ceramic minerals, including borates. Italian ceramic production was expected to remain at 2009 levels until 2011 (Industrial Minerals, 2009b).

Serbia.—Erin Ventures Inc. entered into a binding agreement with the Serbian state-owned coal mining company, JP PEU, for joint development of the Piskanja borate deposit in southern Serbia. Additionally, Erin Ventures was seeking monetary compensation totaling $15 million from Elektroprevreda, the Serbian national power corporation, over an alleged 1997 breach of contract in the development of the Piskanja deposit (O'Driscoll, 2010).

Rio Tinto Minerals held a license to the Jadar borate lithium deposit 150 km north of the Piskanja deposit and was planning further exploration drilling in 2010. The company expected to produce borate by 2015 (Industrial Minerals, 2009e; O'Driscoll, 2010).

Turkey.—The main borate producing areas of Turkey are Bigadic, Emet, Kestelek, Kirka, and Sultancayiri, all controlled by Eti Maden AS, the Turkish state-owned mining company. Production of refined borates increased during the past few years owing to continued investment in new refineries and technologies. However, sales of Turkish borate exports to the United States and Europe plunged in 2009 owing to the economic downturn, totaling $420 million compared with $488 million in 2008 (Today's Zaman, 2009).

Eti Maden planned to expand its share in the world boron market from 36% to 39% by 2013, increasing sales to $1 billion by expanding its production facilities and product range (Today's Zaman, 2009). In 2009, Turkey exported 4 Mt of borates valued at $104 million (Uyanik, 2010).

Outlook

Because U.S. demand for boron glass greatly depends on the construction industry, this sector was significantly affected by the 2008 economic downturn. With a potential recovery forecasted, U.S. consumption was projected to expand 2.3% per year through 2011, totaling 3.7 Mt of fiberglass in 2011 (Weizer, 2007). Europe and emerging markets are requiring higher building standards, which directly correlate to higher consumption of insulation fiberglass. Global consumption of liquid-crystal display televisions, which use small amounts of borates, was expected to double by 2012. Consumption of borates used in high-tech applications was expected to increase by 13% in Europe and 10% in North America by 2012 (Tran, 2008).

Research into boron use in nanotechnology is progressing rapidly, with studies constructing more stable forms of boron nanotubes and developing more efficient fabrication techniques. In 2009, a team of material scientists created the first high-quality, uniformly crystalline boron nitride nanotubes in large qualities (EurekAlert, 2010). Boron nanotubes were expected to overtake carbon nanotubes as the ideal material in nanoengineering, because boron nanotubes can be configured as electrical conductors, a property not inherent to carbon nanotubes (Battersby, 2008; Oku, 2008, p. 335–350).

The European Chemical Agency has declared the use of boric acid in the development of photographs to pose no health risk to consumers with the proper handling of the chemicals. This ruling was considered to have wider implications for the use of borates used in other applications, such as in the ceramic and glass industries (Industrial Minerals, 2010a).

Chinese Nd-Fe-B magnet production is expected to increase 25% per year through 2014, driven by an increase in high-technical applications. With boron content in Nd-Fe-B magnets averaging 18% to 22%, the Chinese boron industry was investigating ways to expand the use of boron from its low-grade deposits through more efficient and effective processes (Industrial Minerals, 2010b).

With the increase in government involvement and funding into "greener" policies, a greater importance has been placed on the development of alternative automotive power sources. The use of fuel cells has for decades been a viable solution, but commercially did not come to true fruition until recently with the greater use of lithium-ion batteries. Sodium tetrahydroborate is a principal component in direct borohydride fuel cells (DBFC), which have been successfully produced for several small-scale uses. Although considered a hydrogen fuel cell, DBFC differs from traditional hydrogen fuel cell in that hydrogen is produced as the waste product (exhaust) with sodium tetrahydroborate and water being the input fuels. This design is advantageous since hydrogen can be stored and then reused as the input fuel for another hydrogen fuel cell (Moores, 2008).

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TABLE 1

SALIENT STATISTICS OF BORON MINERALS AND COMPOUNDS[1]

(Thousand metric tons and thousand dollars)

	2005	2006	2007	2008	2009
United States:					
Sold or used by producers:					
Quantity:					
Gross weight[2]	1,150	W	W	W	W
B_2O_3 content	612	W	W	W	W
Value	713,000	W	W	W	W
Exports:[3]					
Boric acid:[4]					
Quantity	183	221	248	303	171
Value	96,800	126,000	124,000	165,000	109,000
Sodium borates:					
Quantity	308	393	446	519	417
Value	110,000	138,000	146,000	192,000	176,000
Imports for consumption:					
Borax:[3]					
Quantity	1	2	1	1	(5)
Value	319	701	647	566	376
Boric acid:[3]					
Quantity	52	85	67	50	36
Value	22,500	34,900	27,500	26,200	26,100
Colemanite:					
Quantity[6]	31	25	26	30	31
Value	8,900	7,260	7,640	8,880	8,630
Ulexite:					
Quantity[6]	103	131	92	75	28
Value	31,000	39,200	27,600	22,600	11,300
Consumption, B_2O_3 content	W	W	W	W	W
World, production[7]	4,950	3,760	4,200	3,850 [r]	3,510 [e]

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Minerals and compounds sold or used by producers, including actual mine production, and marketable products.

[3] Source: U.S. Census Bureau.

[4] Includes orthoboric and anhydrous boric acid. Harmonized Tariff Schedule of the United States codes 2840.19.0000, 2840.20.0000, and 2840.30.0000.

[5] Less than ½ unit.

[6] Source: Journal of Commerce Port Import/Export Reporting Service.

[7] U.S. production withheld from world production in 2006–09 to avoid disclosing company proprietary data.

TABLE 2
BORON MINERALS OF COMMERCIAL IMPORTANCE

Mineral[1]	Chemical composition	B_2O_3, weight percentage
Boracite (stassfurite)	$Mg_3B_7O_{13}Cl$	62.2
Colemanite	$Ca_2B_6O_{11}{\cdot}5H_2O$	50.8
Datolite	$CaBSiO_4OH$	24.9
Hydroboracite	$CaMgB_6O_{11}{\cdot}6H_2O$	50.5
Kernite (rasortie)	$Na_2B_4O_7{\cdot}4H_2O$	51.0
Priceite (pandermite)	$CaB_{10}O_{19}{\cdot}7H_2O$	49.8
Probertite (kramerite)	$NaCaB_3O_9{\cdot}5H_2O$	49.6
Sassolite (natural boric acid)	H_3BO_3	56.3
Szaibelyite (ascharite)	$MgBO_2OH$	41.4
Tincal (natural borax)	$Na_2B_4O_7{\cdot}10H_2O$	36.5
Tincalconite (mohavite)	$Na_2B_4O_7{\cdot}5H_2O$	47.8
Ulexite (boronatrocalcite)	$NaCaB_5O_9{\cdot}8H_2O$	43.0

[1] Parentheses indicate common names.

TABLE 3
YEAREND PRICES FOR BORON MINERALS AND COMPOUNDS[1]

(Dollars per metric ton)

Product	Price, December 31, 2008	Price, March 31, 2009	Price, December 31, 2009[2]
Borax, anhydrous, 25 kg bags	1,223–1,310	1,194–1,279	NA
Borax, decahydrate	340–380	340–380	NA
Borax, decahydrate, Buenos Aires	560	560	520
Borax, decahydrate, granular	582–655	569–640	NA
Borax, pentahydrate	400–430	400–430	NA
Borax, pentahydrate, granular	437-509	426–497	NA
Boric acid, Chile	950	950	800
Boric acid, granular	509-582	497–569	NA
Colemanite, Buenos Aires, 40% boron oxide (B_2O_3)	420–460	420–460	370–420
Colemanite, Turkish lump, 40%-42% boron oxide (B_2O_3)	270–290	270–290	NA
Ulexite, Buenos Aires, 40% B_2O_3	390–410	390–410	350–380
Ulexite, granular, Chile, 40% B_2O_3	500	500	400
Ulexite, Lima, 40% B_2O_3	490–520	490–520	250–300

NA Not available.

[1] U.S. free on board plant or port prices per metric ton of product. Other conditions of final preparation, transportation, quantities, and qualities not stated are subject to negotiation and (or) somewhat different price quotations. Values have been rounded to the nearest dollar.

[2] Industrial Minerals ceased publication of seven boron products on April 1, 2009.

Source: Industrial Minerals, no. 495, December 2008, p. 88; no. 498, March 2009, p. 68; no. 507, December 2009, p. 68.

TABLE 4
U.S. EXPORTS OF BORIC ACID AND REFINED SODIUM BORATE COMPOUNDS, BY COUNTRY[1]

	2008			2009		
	Boric acid[2]		Sodium borates[4]	Boric acid[2]		Sodium borates[4]
Country	Quantity (metric tons)	Value[3] (thousands)	(metric tons)	Quantity (metric tons)	Value[3] (thousands)	(metric tons)
Australia	3,100	$1,690	7,750	3,990	$2,550	9,310
Belgium	64	129	265	132	172	259
Brazil	1,840	1,970	4,060	448	613	3,300
Canada	4,210	3,090	38,100	2,970	2,440	27,500
China	73,400	37,900	109,000	26,500	14,500	146,000
Colombia	347	383	6,240	190	250	3,990
France	12,700	7,860	514	4,280	5,270	312
Germany	357	851	12	316	532	1
Hong Kong	2,060	1,050	125	--	--	4
India	1,890	941	26,200	1,530	1,200	17,400
Indonesia	1,690	966	3,140	833	532	4,770
Italy	1	3	240	--	--	2,400
Japan	33,900	21,400	26,600	22,800	16,700	19,500
Korea, Republic of	35,500	19,500	17,600	38,800	21,700	12,700
Malaysia	2,140	1,110	64,200	206	124	32,400
Mexico	5,360	3,770	13,500	6,600	5,350	16,900
Netherlands	55,000	26,600	121,000	23,000	13,200	85,900
New Zealand	717	397	1,530	361	212	1,930
Philippines	105	82	1,910	54	38	1,360
Singapore	1,750	1,200	801	847	1,170	578
Spain	24,500	11,200	41,500	3,000	1,700	5,890
Taiwan	32,700	17,300	5,560	25,100	13,900	2,900
Thailand	4,700	2,650	8,830	2,850	1,620	6,340
United Kingdom	55	77	16	49	71	4
Venezuela	63	104	522	82	198	501
Vietnam	1,380	772	3,240	3,280	2,040	4,230
Other	3,300	2,010	17,300	2,990	2,620	10,700
Total	303,000	165,000	519,000	171,000	109,000	417,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States (HTS) code 2810.00.0000.

[3] Free alongside ship valuation.

[4] HTS codes 2840.19.0000, 2840.20.0000, and 2840.30.0000.

Source: U.S. Census Bureau.

TABLE 5

U.S. IMPORTS FOR CONSUMPTION OF BORIC ACID, BY COUNTRY[1]

	2008		2009	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Argentina	112	$95	841	$637
Bolivia	2,480	1,830	2,440	1,550
Chile	6,650	4,430	6,550	4,390
China	222	141	125	228
France	716	1,210	750	1,190
Germany	35	51	21	20
India	275	289	192	257
Italy	1,310	1,550	1,110	1,250
Japan	13	30	82	77
Peru	2,170	1,760	1,140	896
Russia	--	--	4,380	2,920
Turkey	35,900	14,600	18,300	12,600
United Kingdom	216	218	54	54
Other	5	18	46	43
Total	50,100	26,200	36,100	26,100

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] U.S. customs declared values.

Source: U.S. Census Bureau.

TABLE 6
BORON MINERALS: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2005	2006	2007	2008	2009[e]
Argentina	633	534	670	786	750
Bolivia, ulexite	63	51 [r]	64 [r]	56	83 [p, 3]
Chile, ulexite	461	460	528	583	608 [3]
China[e, 4]	140	145	145	140	145
Iran, borax[e, 5]	2	2	2 [3]	2	2
Kazakhstan[e]	30	30	30	30	30
Peru	120	191	234	350	187 [3]
Russia[e, 6]	400	400	400	400	400
Turkey[7]	1,953	1,948	2,128	1,500 [r, e]	1,300
United States[8]	1,148	W	W	W	W
Total	4,950	3,760	4,200	3,850 [r]	3,510

[e] Estimated. [p] Preliminary. [r] Revised. W Withheld to avoid disclosing company proprietary data, not included in total.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 23, 2010.

[3] Reported figure.

[4] Boron oxide (B_2O_3) equivalent.

[5] Data are for years beginning March 21 of that stated.

[6] Blended Russian datolite ore that reportedly grades 8.6% B_2O_3.

[7] Concentrates from ore.

[8] Minerals and compounds sold or used by producers, including both actual mine production and marketable products.

BROMINE

By Lori E. Apodaca

Domestic survey data and tables were prepared by Michelle B. Blackwell, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

The United States was the world's leading producer of bromine; however, the U.S. portion of world production has decreased steadily since 1973, when the United States produced 71% of the world supply. World production of bromine for 2009, excluding the United States, was estimated to be 375,000 metric tons (t) compared with 412,000 t in 2008 (tables 1, 6). The world producers of bromine included China, Israel, Jordan, the United States, and seven other countries. In 2009, bromine sold or used in the United States was estimated to have decreased from 243,000 t valued at $339 million produced in 2006 (table 1); however, data were withheld to avoid disclosing company proprietary data.

Bromine is one of two elements that are liquid at room temperature and is found principally as a dissolved species in seawater, evaporitic (salt) lakes, and underground brines associated with petroleum deposits. Primary uses of bromine compounds were in flame retardants (FRs), drilling fluids, water treatment, and brominated pesticides (mostly methyl bromide).

Production

Domestic production data for bromine were developed by the U.S. Geological Survey (USGS) from a voluntary canvass of the two U.S. producers (table 2). Albemarle Corp. and Chemtura Corp., both of which responded to the survey, represent 100% of total production. Production data collected by the USGS were withheld to avoid disclosing proprietary information (table 1).

Bromine was recovered from brine wells in Arkansas where brine is found in the Smackover Formation at a depth of about 2,400 meters with concentrations of 4,000 to 5,000 parts per million (ppm) bromine; by comparison, seawater contains 65 ppm bromine.

After bromine processing, the spent brine is returned underground into the production formation by class V injection wells that are regulated by the U.S. Environmental Protection Agency (EPA). The chemical composition of the spent brine is generally similar to that of the original, except that the concentration of the target elements (such as bromine and magnesium) is reduced, and the concentration of other elements (such as calcium) may have increased through substitution (U.S. Environmental Protection Agency, 1999, p. 1–2, 5).

Recycling

Some bromide solutions were recycled to obtain elemental bromine and to prevent the solutions from being disposed of as hazardous waste. Hydrogen bromide is emitted as a byproduct from many organic reactions. This byproduct waste is recycled with virgin bromine brines and is a major source of bromine production. Plastics containing brominated FRs (BFRs) can be incinerated as a solid organic waste, and the bromine can be recovered (Frim and Ukeles, 2007).

Consumption

The USGS did not collect consumption data on bromine compounds. Apparent consumption of bromine in the United States, calculated by the USGS from production plus imports minus exports, was estimated to have decreased in 2009 owing to the decline in demand. The major consumption categories, in order of magnitude, were FRs, drilling fluids, water treatment, and pesticides. Other uses included butyl rubber, dyes, mercury emissions, pharmaceuticals, photographic chemicals, and surfactants.

An estimated 50% of bromine consumption was in BFRs, chemicals commonly used in many domestic and industrial appliances and equipment, such as computers, furniture, insulation boards, mattresses, mobile telephones, televisions, and textiles. About 90% of all electrical components contain BFRs.

Albemarle and Chemtura reached an agreement with the EPA for a voluntary phaseout of decabromodiphenyl ether (decaBDE) flame retardant. DecaBDE is used in consumer electronics, furniture, plastic shipping pallets, and textiles. The two companies signed a memorandum of understanding (MOU) with the EPA to end production, importation, and sales of decaBDE for most uses by December 2012 and for all uses by the yearend 2013 (U.S. Environmental Protection Agency, 2009a).

Calcium bromide, sodium bromide, and zinc bromide, collectively referred to as clear brine fluids (CBFs), were used in the oil- and gas-well-drilling industry for high-density, solids-free completion, packer, and workover fluids to reduce the likelihood of damage to the well bore and productive zone. These high-density fluids also help to prevent migration of fluids between underground formations through the well bore.

Another major use of bromine is as a water purifier and disinfectant, which is an alternative to using chlorine. Brominated compounds are used for water treatment in hot tubs and swimming pools and to control algae and bacterial growth in industrial processes.

Bromine compounds are effective pesticides, used both as soil fumigants in agriculture, particularly fruit growing, and as a fumigant to prevent pests from attacking stored grain and other produce. World trade in agricultural goods depends on the use of bromine compounds to ensure compliance with mandatory quarantine rules. Bromine compounds also are used as intermediates to make other agricultural chemicals. Methyl bromide is the leading bromine-containing pesticide in the world, but its use is declining owing to the ban imposed by the 1987 Montreal Protocol, which classified it as a class I ozone-depleting substance. As part of the Montreal Protocol, wealthy countries were to stop using the pesticide by 2005; however, the United States has received annual exemptions for crops and other critical uses (for example, cucumbers, melons, orchard replants, peppers, post-harvest uses, squash, strawberries, and tomatoes). In 2009, the EPA authorized use of 4,195 t or 16.4% of the historic 1991 baseline consumption of methyl bromide for approved critical uses (U.S. Environmental Protection Agency, 2009b, p. 16). Methyl bromide is a broad spectrum pesticide used in the control of nematodes, pathogens, pest insects, rodents, and weeds. Domestically, methyl bromide had proven to be difficult to replace because of its low cost and usefulness against a large variety of agricultural pests.

Bromide-base technologies to remove mercury emissions at coal-fired powerplants are an area of potential growth for the industry. Albemarle signed an MOU with MeadWestvaco Corp. to form a partnership to develop a domestic supply of activated carbon to remove mercury from coal-fired plant emissions. The two companies were to continue to develop brominated wood-based activated carbons for use in mercury control (Albemarle Corp., 2009). Chemtura had also developed bromine and brominated derivative products for use in the control of mercury emissions from coal-fired plants (Chemtura Corp., 2009).

Transportation

Bromine in bulk quantities is transported in the United States in 7,570- and 15,140-liter (L) lead-lined pressure tank railcars or 6,435- to 6,813-L nickel-clad pressure tank trailers. The trailers must be filled at least 92% full to prevent inertia effects of the heavy liquid while on the highway. International shipments by The Dead Sea Bromine Group are in 15.2- to 23.3-t lead-lined tank containers (isotanks) with a volume of 5,300 to 8,000 L. For smaller quantities, lead lined tanks ("goslars") of 3.5 t (four tanks packed on one isoframe) and cylinders of 400 kilograms are used. Dry nitrogen gas is recommended for use in pressure transferring bromine, although dry air may be used. The gas used must be absolutely dry or severe corrosion results. When exposed to a high-humidity atmosphere, the water content of bromine can exceed 300 ppm. If the water content exceeds 70 ppm, the corrosiveness of bromine to many metals increases (Frim and Ukeles, 2007).

Prices

In the beginning of 2009, prices for bromine and bromine compounds were lower as a result of the poor market conditions worldwide. Prices began to rebound in the latter part of 2009 owing to increased demand. The increase in bromine and bromine compound prices reflected the rising market value of bromine and increases in the cost of energy, key raw materials, regulatory compliance, and transportation.

Bromine exports were about 36% lower than those in 2008 (tables 1, 3). The value of exported elemental bromine and bromine compounds decreased by 23% compared with that of 2008. Bromine imports were about 17% lower than those of 2008. The value of imported elemental bromine and some bromine compounds increased, with the exception of ammonium bromide, potassium bromate, sodium bromate, methyl bromide, tetrabromobisphenol A, decabromodiphenyl oxide, and octabromodiphenyl oxide (tables 1, 4). Overall the import value for elemental bromine and bromine compounds decreased by 14% in 2009.

World Review

The U.S. share of world bromine production has decreased as other countries have strengthened their positions as world producers of elemental bromine. Israel, the United States, Jordan, China, Japan, and Turkmenistan, in descending order, had the leading bromine production capabilities in 2009 (table 5).

Canada.—Environment Canada has issued a performance agreement to control, monitor, and minimize the release of decaBDE from Canadian facilities where decaBDE is used or handled. The proposed agreement aims to manage and reduce releases of decaBDE from its use in plastic and textile manufacturing facilities (Environment Canada, 2009, p. 2)

China.—Shouguang City Haoyuan Chemical Company Ltd. (SCHC) (a subsidiary of Gulf Resources, Inc.) started production of the bromine assets acquired in January. The assets were expected to add an additional 4,000 metric tons per year (t/yr) of bromine production capacity, increasing capacity to 38,700 t/yr (Gulf Resources, Inc., 2009a, b).

Israel.—ICL Industrial Products (a subsidiary of Israel Chemicals Ltd.) began a program designed to accelerate the market's transition to sustainable flame retardant solutions by developing next-generation polymeric flame retardants and beginning a 3-year phaseout of sales of decaBDE to the U.S. market (ICL Industrial Products, 2009).

ICL has developed a bromine compound to remove mercury emission from coal-fired powerplants and, to a lesser degree, emissions by hazardous substance kilns, production of chlorine, and incineration of medical waste products (ICL Industrial Products, 2010).

Outlook

Between 40% and 50% of domestic consumption of bromine is for FRs. In the first half of 2009, demand for FRs, particularly in the construction and electronics industries, declined as a result of the poor market conditions. Although FR usage fluctuates along with overall cycles in the economy, world consumption of FRs is expected to increase, assuming sustained economic growth. Recycling efforts in Europe for BFR plastics in electrical usage, which are easier to recycle than some other FR compounds, may increase the demand for BFR products. BFR products are thought to be more environmentally friendly, especially where recycling is an important concern, such as in Europe and Japan. However, use of BFRs will likely increase at a slower pace owing to legislative mandates and customer demand for more environmentally friendly materials.

The Freedonia Group forecast FR global consumption to rise by 4.7% per year through 2011 (Freedonia Group, The, 2007). The increase would be driven by the use of FRs in developing countries as they begin to adopt more stringent flammability standards and begin to use more plastic materials. Asia and the Pacific would be the leading consumer of FRs, with consumption rising by 7% per year. More moderate growth in FR use was expected for markets in North America and Western Europe. U.S. demand was forecast to rise by 2.7% per year through 2013 as a result of bromine use in insulated wire and cable and in construction as well as more stringent fire codes and flammability requirements (Freedonia Group, The, 2009a). Above-average gains in the demand for FRs were expected to take place in Africa, Eastern Europe, the Middle East, and Latin America.

Bromine use in CBFs is highly dependent on fluctuations in the oil and natural gas drilling industry. Oil and gas drilling activity in the United States was lower in 2009 than in 2008 as a result of the economic downturn. Production for crude oil and natural gas production was expected to increase as demand for these commodities increases.

Bromine water treatment chemical use was expected to show modest growth during the next several years. Bromine is used in both commercial and residential hot tubs, swimming pools, and whirlpools. In addition, bromine is used to treat industrial cooling water. Bromine has been found to be safer than its substitutes in sanitary preparations because bromine has a higher biocidal activity level for the same volume of product. The use of bromine compounds was expected to continue increasing in the hot tub, spa, and swimming pool sector as a gentler disinfectant than chlorine. Global demand for water treatment products was projected to increase in developing markets, such as China and India, as a result of continued industrial expansion and increased efforts to expand access to safe water supplies (Freedonia Group, The, 2009b).

Bromine use in photography is declining as digital imaging replaces film in consumer and professional photography. Most feature films for movie theater presentation are shot using printed film; however, the use of digital technology was expected to increase and overtake film in these applications during the next decade.

The market potential for bromide-base technologies to remove mercury emissions at coal-fired powerplants is expected to be an area of potential growth for the industry. Using bromide compounds to neutralize mercury emissions appears to be more cost effective compared with other materials like chlorine-, fluorine-, or iodine-base compounds.

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TABLE 1
SALIENT BROMINE STATISTICS[1]

(Metric tons and thousand dollars)

	2005	2006	2007	2008	2009
United States:					
Bromine sold or used:[2]					
Quantity	226,000	243,000	W	W	W
Value	168,000	339,000	W	W	W
Exports:[3]					
Quantity	9,740	12,400	8,560 r	9,640 r	6,120
Value	16,800	23,000	15,200 r	16,200 r	12,400
Imports for comsumption:[4]					
Quantity	59,100	43,100	32,200 r	41,200 r	34,200
Value[5]	55,800	78,100	817,000 r	97,300 r	83,300
Apparent consumption	277,000	275,000	W	W	W
World, production[e]	654,000 r	669,000	408,000 r, 6	412,000 r, 6	375,000 [6]

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Elemental bromine sold as such to nonproducers, including exports, or used by primary U.S. producers in preparing bromine compounds.

[3] Export values are free alongside ship.

[4] Source: U.S. Census Bureau or United Business Media Global Trade Port Import/Export Reporting Service (see table 4).

[5] Import values are cost, insurance, and freight.

[6] Excludes U.S. production.

TABLE 2
ELEMENTAL-BROMINE-PRODUCING PLANTS IN THE UNITED STATES IN 2009

State and company	County	Plant	Production source	Capacity[1] (thousand metric tons)
Arkansas:				
Albemarle Corp.	Columbia	Magnolia South	Well brines	NA
Do.	do.	Magnolia West	do.	NA
Do.	Union	Satellite plants	do.	NA
Total				148 [2]
Chemtura Corp.	do.	El Dorado Central and El Dorado South	do.	71 [3]
Do.	do.	Marysville West	do.	36
Do.	do.	Newell	do.	23
Total				59
Grand total				278

Do., do. Ditto. NA Not available.

[1] Actual production capacity is limited by brine availability.

[2] Cumulative capacity of Magnolia South, Magnolia West, and Satellite plants.

[3] Cumulative capacity of El Dorado Central and El Dorado South plants.

TABLE 3

U.S. EXPORTS OF BROMINE AND BROMINE COMPOUNDS[1, 2]

		2008			2009		
	HTS[3]	(metric tons)		Value[4]	(metric tons)		Value[4]
Compound	number	Gross weight	Br equivalent	(thousands)	Gross weight	Br equivalent	(thousands)
Elemental bromine	2801.30.2000	6,140	6,140	$7,100	3,810	3,810	$5,930
Other compounds:							
Ethylene dibromide	2903.31.0000	2,750 r	2,340 r	5,840 r	1,760	1,500	4,320
Methyl bromide	2903.39.1520	1,380 r	1,160 r	3,280 r	968	815	2,190
Grand total		10,300 r	9,640 r	16,200 r	6,540	6,120	12,400

[r] Revised.

[1] These data detail the information included in table 1 under "Exports."

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Harmonized Tariff Schedule of the United States.

[4] Declared cost, insurance, and freight valuation.

Source: U.S. Census Bureau.

TABLE 4

U.S. IMPORTS OF BROMINE AND BROMINE COMPOUNDS[1, 2]

Compound	HTS[3] number	2008 Gross weight (metric tons)	2008 Br equivalent (metric tons)	2008 Value[4] (thousands)	2009 Gross weight (metric tons)	2009 Br equivalent (metric tons)	2009 Value[4] (thousands)	Principal sources in 2009
Elemental bromine	2801.30.2000	1,950	1,950	$2,280	1,390	1,390	$3,020	Israel, 95%.
Bromine compounds:								
Ammonium bromide	2827.59.2500	37,000	30,200	56,500	25,600	20,900	39,200	Israel, 85%; Germany, 11%.
Calcium bromide[5]	2827.59.2500	684	547	595 [e]	1,760	1,410	1,690 [e]	China, 64%; Israel, 30%.
Potassium bromate	2829.90.0500	84	40	349	54	26	203	China, 100%.
Potassium bromide[5, 6]	2827.51.0000	272	182	1,030 [e]	279	187	1,170 [e]	Israel, 78%; China, 16%.
Sodium bromate	2829.90.2500	686	363	1,810	223	118	547	China, 99%.
Sodium bromide[5, 6]	2827.51.0000	4,320	3,350	7,050 [r, e]	6,490	5,040	11,900 [e]	Israel, 57%; China, 30%; Belgium, 13%.
Other compounds:								
Hydrobromic acid	2811.19.3000	422	417	483	970	958	1,520	Israel, 52%; France, 33%; United Kingdom, 14%.
Ethylene dibromide	2903.31.0000	84 [r]	71 [r]	53 [r]	105	89	178	Israel, 85%; Japan, 13%.
Methyl bromide	2903.39.1520	647 [r]	545 [r]	4,850 [r]	565	476	4,260	Israel, 98%.
Dibromoneopentyl glycol[5]	2905.50.3000	536	306	NA	606	345	NA	China, 90%; Israel, 10%.
Tetrabromobisphenol A	2908.19.2500	1,140 [r]	675 [r]	7,760 [r]	1,860	1,100	7,250	Israel, 63%; Jordan, 35%.
Decabromodiphenyl oxide and octabromodiphenyl oxide	2909.30.0700	4,480	2,580	14,500	3,810	2,190	12,400	Israel, 92%.
Grand total		52,300 [r]	41,200 [r]	97,300 [r]	43,700	34,200	83,300	

[e] Estimated. [r] Revised. NA Not available.

[1] These data detail the information included in table 1 under "Imports for consumption."

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Harmonized Tariff Schedule of the United States.

[4] Declared cost, insurance, and freight valuation.

[5] Source: United Business Media Global Trade Port Import/Export Reporting Service.

[6] Potassium bromide and sodium bromide import data are reported under a common HTS number, 2827.51.0000.

Source: U.S. Census Bureau.

TABLE 5

WORLD BROMINE ANNUAL PLANT CAPACITIES AND SOURCES AS OF DECEMBER 31, 2009[1]

Country and company or plant	Location	Capacity (metric tons)	Source
Azerbaijan, Neftechala Bromine Plant	Baku	4,000	Underground brines.
China, Laizhou Bromine Works	Shandong	43,000	Do.
India:			
Hindustan Salts Ltd.	Jaipur	NA	Seawater bitterns from salt production.
Mettur Chemicals Ltd.	Mettur Dam	NA	Do.
Tata Chemicals Ltd.	Mithapur	NA	Do.
Total		1,500	
Israel, ICL Industrial Products	Sdom	280,000	Bitterns of potash production from surface brines.
Japan, Toyo Soda Manufacturing Co. Ltd.	Tokuyama	20,000	Seawater.
Jordan, Jordan Bromine Co. Ltd.	Safi	50,000	Bitterns of potash production from surface brines.
Spain, Derivados del Etilo S.A.	Villaricos	900	Seawater.
Turkmenistan:			
Cheleken Chemical Plant	Cheleken Region	4,740	Do.
Nebitdag Iodine Plant	Vyshka	2,370	Underground brines.
Ukraine, Perekop Bromine Plant	Krasnoperekopsk	3,000	Do.

Do. ditto. NA Not available.

[1] Excludes U.S. production capacity, which is detailed in table 2.

TABLE 6
BROMINE: ESTIMATED WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009
Azerbaijan	2,000	2,000	2,000	3,500	3,500
China	104,500 [5]	124,000	137,000 [r]	135,000	140,000
Germany[4]	274 [5]	431 [5]	1,612 [5]	1,680 [r]	1,400
India	1,500	1,500	1,500	1,500	1,500
Israel	207,048 [5]	179,493 [5]	159,395 [r, 5]	164,042 [r, 5]	128,000 [5]
Japan	20,000	20,000	20,000	20,000	20,000
Jordan	89,785 [5]	94,500 [5]	85,105 [5]	85,000	80,000
Spain	100	100	100	100	100
Turkmenistan	150	150	150	150	150
Ukraine	1,878 [r, 5]	3,138 [r, 5]	700 [r]	700 [r]	700
United States[6]	226,000 [5]	243,000 [5]	W	W	W
Total	654,000 [r]	669,000	408,000 [r, 7]	412,000 [r, 7]	375,000 [7]

[r] Revised. W Withheld to avoid disclosing company proprietary data; not included in total.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 13, 2010.

[3] In addition to the countries listed, several other nations, including Iran, produced bromine, but output data were not reported; available general information is inadquate to formulate reliable estimates of output levels.

[4] Includes bromides and oxides.

[5] Reported figure.

[6] Sold or used by producers.

[7] Excludes U.S. production.

CADMIUM

By Amy C. Tolcin

Domestic survey data and tables were prepared by Susan M. Weaver, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2009, estimated cadmium metal production in the United States was 633 metric tons (t), 19% lower than that of 2008 (table 1). Apparent consumption of cadmium was 199 t, a 62% decrease from that of 2008. Cadmium metal (including alloys, powders, and waste and scrap) was primarily exported to China (51%), the Republic of Korea (12%), and Germany (4%) (table 3). Australia (31%), Peru (20%), and Canada (18%) supplied the bulk of the corresponding imports (table 4). The annual average New York dealer price of cadmium metal in 2009 declined by 52% from that of 2008 to $2.87 per kilogram ($1.30 per pound).

In 2009, global primary production of cadmium decreased by 7% to 18,800 t (table 5). Most of the world's primary cadmium was being produced in Asia and the Pacific—specifically China, Japan, and the Republic of Korea—followed by Central Europe and Eurasia, North America, and Western Europe. Global secondary cadmium production accounted for approximately 20% of all cadmium metal production. Most secondary metal was produced from nickel-cadmium (NiCd) battery recycling.

Leading consumers of refined cadmium were—in descending order of quantity—China, Belgium, and Japan. NiCd battery production continued to be the leading end use of cadmium, accounting for the majority of global cadmium consumption. Other significant end uses of cadmium included alloys, anticorrosive coatings, pigments, polyvinylchloride stabilizers, and semiconducting compounds for solar cells. The percentage of cadmium consumed globally for NiCd battery production has been increasing, while the percentages for the other traditional end uses of cadmium—specifically, coatings, pigments, and stabilizers—have gradually decreased because of environmental and health concerns. Most of the NiCd battery market was concentrated in Asia. Cadmium metal is sold in several shapes and forms, which are used for different types of consumption. Slabs or sticks are commonly consumed for alloys; balls and spheres for plating; and flakes, powder, or sticks for chemicals and pigments.

Production

Mine production.—Data on domestic mine production of cadmium were not collected by the U.S. Geological Survey (USGS). Primary cadmium is generally recovered from zinc concentrates. The cadmium content of typical zinc ores ranges from 0.2% to 0.3%. Sphalerite (ZnS), the most economically significant zinc mineral, is commonly impure; cadmium will often substitute for zinc in the crystal lattice. The cadmium mineral greenockite (CdS) is frequently associated with weathered sphalerites and wurtzites [(Zn, Fe)S], but usually at microscopic levels. In 2009, zinc-concentrate-producing States included Alaska, Idaho, Missouri, Tennessee, and Washington.

Metal production.—Domestic metal production data were collected by the USGS from a voluntary survey on production of cadmium metal and compounds. In 2009, cadmium metal was produced in three States—Ohio (Toxco, Inc.'s Lancaster facility), Pennsylvania [The International Metals Reclamation Co., Inc. (INMETCO's Ellwood City facility)], and Tennessee [Nyrstar NV's (Balen, Belgium) Clarksville facility].

Primary.—Clarksville (owned and operated by Nyrstar) is an electrolytic zinc refinery located along the Cumberland River 80 kilometers (km) northwest of Nashville, TN. The complex's main products were Special High Grade Zinc, galvanizing alloy, and byproducts including cadmium metal, intermediate copper cementate, leach product, sulfuric acid, and synthetic gypsum. Cadmium-bearing zinc concentrates were partially sourced from the recently reopened Tennessee Valley zinc mines. Remaining concentrates were imported.

Secondary.—INMETCO produced secondary cadmium metal (ingot and shot) at its metals recovery facility in Ellwood City, PA. The company was established in 1978 to process stainless steel wastes and then expanded in December 1995 to recycle NiCd batteries. The cadmium recovery plant thermally recovered cadmium from both large industrial and portable consumer NiCd batteries in eight cadmium retort furnaces. The bulk of the cadmium metal produced was sold back to battery manufacturers. Chromium and nickel were also reclaimed in the recovery process as a ferrous remelt alloy for stainless steel production. In addition to NiCd batteries, INMETCO also processed alkaline, lithium, magnesium, nickel chloride, nickel iron, nickel metal hydride, and zinc carbon batteries. On December 31, Horsehead Holding Corp. (Monaca, PA) acquired INMETCO from Vale Inco Ltd. (Toronto, Ontario, Canada) to increase its share of the battery recycling market and to recover metals from industrial wastes besides electric arc furnace (EAF) dust.

Toxco's (Anaheim, CA) recycling operations in Lancaster, OH, also produced secondary cadmium metal in the form of ingots. Cadmium was recovered from NiCd batteries in 12 cadmium retort furnaces, each with a 249-kilogram production capacity. Nickel-iron cells were also produced during the recycling process. Toxco acquired the cadmium recovery equipment from Moltech Power Systems Inc.'s (Marietta, GA) idled battery manufacturing facility in Gainesville, FL.

Consumption

Coatings and plating.—Cadmium coatings and plating can be applied to certain metals to prevent their corrosion. The amount of cadmium consumed for coatings and plating has decreased domestically during the past several decades as cadmium plated parts were phased out of motor vehicles by the automotive industry. However, cadmium coatings were still used by the aerospace industry and military for some critical applications where coating substitution may compromise operational safety;

the metal is commonly used to plate fasteners in aircraft landing gear and parachutes owing to a combination of properties not present in other anticorrosive coatings.

Nickel-cadmium batteries.—Reactions within a NiCd rechargeable battery take place between the nickel compounds at the positive electrode and between the cadmium compounds at the negative electrode. NiCd batteries have a high number of charge-discharge cycles, high rate of energy discharge, and a wide operating temperature. They power portable consumer electronics (commonly power tools) and provide emergency backup power for industrial applications and aircraft electrical systems.

Domestically, NiCd batteries were thought to have been produced at six facilities operated by four battery manufacturing companies. Globally, leading NiCd battery manufacturers included BYD Co., Ltd. (Pingshan, Shenzhen Province, China), Panasonic Corp. (Japan), and Sanyo Electric Co., Ltd. (Japan). NiCd battery use in consumer electronics was thought to be declining owing partly to the preference for other rechargeable battery chemistries—particularly lithium ion (Li-ion) batteries, which have already replaced NiCd batteries in cellular telephones and laptops owing to their high energy density. However, NiCd batteries have a cost advantage compared with other battery chemistries and are still favored for use in less expensive consumer appliances and electronics.

Industrial-sized NiCd batteries potentially could be used to store energy produced by certain on-grid solar or wind systems. About 2% of the Nation's power was generated by solar cells and wind farms. If this percentage were to increase to more than 10%, mass energy storage may be required for load leveling. Peak energy could be stored in a battery storage system, from which it would be later dispatched during periods of high electricity demand. NiCd batteries may be a favored battery chemistry for this use owing to their stability in offshore and harsh weather environments.

Pigments.—Cadmium pigments are inorganic and based on cadmium sulfide, which is golden yellow in color. The increased replacement of zinc or mercury for cadmium and selenium for sulfur forms the spectrum of cadmium pigments that range in color from bright yellow to maroon. Cadmium pigments are predominantly used to color plastics that are processed at higher temperatures; the pigments are able to withstand the elevated temperatures without degrading.

Solar cells.—Cadmium telluride (CdTe) flexible thin-film solar cells are an alternative to traditional crystalline silicon solar cells and are practical for commercial rooftop applications and large-scale, ground-mounted utility systems. CdTe photovoltaic cells are potentially a safe, environmentally friendly application for cadmium; the cadmium would remain contained and recyclable. CdTe cells contain an average of 7 grams (g) of cadmium per square meter. This equates to 70 g of cadmium per kilowatt of electric power produced, assuming the cells are 10% efficient. Companies involved in developing CdTe thin-film technology within the United States included Ascentool, Inc., AVA Solar, Inc., Canrom Photovoltaics, Inc., China Nuvo Solar Energy, First Solar, Inc., Primestar Solar, Inc., Solar Fields LLC, and Zia Watt Solar (Ullal and von Roedern, 2007).

Prices

Platts Metals Week publishes a weekly and monthly New York Dealer price for cadmium (minimum 99.95% purity) in dollars per pound. The 2009 average New York Dealer price for cadmium was $2.87 per kilogram ($1.30 per pound), 52% less than the average price in 2008. The average monthly New York dealer price in January was $1.82 per kilogram ($0.83 per pound) and rose to $3.51 per kilogram ($1.59 per pound) in December.

World Industry Structure

In 2009, global primary production of cadmium was 18,800 t. Most of the world's primary cadmium (approximately 55%) was being produced in Asia and the Pacific—specifically China, Japan, and the Republic of Korea—Central Europe and Eurasia (19%), North America (17%), and Western Europe (6%).

Global secondary cadmium production was thought to have accounted for approximately 20% of all cadmium metal production. Most secondary metal was produced at NiCd battery recycling facilities in Asia, Europe, and the United States. In Japan, NiCd battery recyclers included Kansai Catalyst Co., Ltd., Mitsui Mining and Smelting Co., Ltd., and Toho Zinc Co., Ltd. In Europe, NiCd battery recycling took place at Accurec GmbH's facility in Germany, Saft AB's plant in Sweden, and Societe Nouvelle D'Affinage des Metaux's two recycling facilities in France.

World Review

Australia.—Most of the cadmium metal produced domestically was exported; a small amount was consumed in the country by specialized electroplating industries. Nyrstar's Hobart zinc smelter, in Tasmania, produced cadmium metal from cadmium-bearing zinc concentrates sourced from the Century and Rosebery zinc-lead mines.

Sun Metals Corporation Pty. Ltd.'s (a subsidiary of Korea Zinc Co., Ltd.) zinc refinery near Townsville, North Queensland, had the capacity to produce 1,000 metric tons per year (t/yr) of cadmium cake (containing 75% to 80% cadmium). Sun Metals was thought to have exported most of the cadmium cake to Korea Zinc's Onsan zinc-lead refinery in the Republic of Korea, where it was refined into metal (Park, undated, p. 5).

Belgium.—Belgium was a significant consumer of refined cadmium. Most of this consumption took place at Floridienne Chimie S.A.'s plant for the production of cadmium compounds (carbonate, nitrate, and oxide) and powder, which were then exported to downstream consumers. It was estimated that the company consumed 4,800 to 7,200 t/yr of refined cadmium, accounting for almost 40% of global cadmium production. In October, Floridienne Chimie appointed MCP Group to source their cadmium metal requirements. Floridienne Chimie held a 40% share of MCP Group (Metal Bulletin, 2009c).

Brazil.—Votorantim Metais' (Sao Paulo, Brazil, a unit of Grupo Votorantim) Juiz de Fora zinc smelter in Minas Gerais was the sole producer of refined cadmium in Brazil.

Canada.—Teck Resources Ltd. (Vancouver, British Columbia, Canada) produced approximately 1,000 t/yr of refined cadmium at its metallurgical complex at Trail, British Columbia. Refined zinc and lead metal were the main products produced at Trail along with a number of byproducts that included copper compounds, germanium dioxide, gold, indium, silver, and various sulfur products. The cadmium plant at Trail was constructed in 1991 to handle the increased cadmium input from the Red Dog Mine in Alaska and can produce up to 1,400 t/yr of refined cadmium. Cadmium metal products, which were mostly consumed by NiCd battery manufacturers, included balls, billets, and sticks. Teck also produced cadmium chemicals and continuously cast cadmium sheet. Cadmium sheet is commonly used to shield radiation measurement and control devices from slow neutrons. HudBay Minerals Inc.'s (Winnipeg, Manitoba) copper smelting and zinc refining operations in Flin Flon, Manitoba, also produced byproduct cadmium metal.

India.—Hindustan Zinc Ltd. (HZL, Udaipur) produced cadmium metal at its Chanderiya lead-zinc smelter complex, Debari zinc smelter, and Vizag zinc smelter. During 2009, the company continued to increase the lead-zinc production capacity at its refineries, which increased its production capacity of byproduct metals, including cadmium and silver. During the financial year ending March 31, 2010, HZL's cadmium metal production capacity was 833 t/yr. Cadmium production capacity by plant was as follows—Chanderiya, 460 t/yr; Debari, 235 t/yr; and Vizag, 138 t/yr. HZL produced 487 t of cadmium during its 2009–10 financial period (Hindustan Zinc Ltd., 2010, p. 52, 100).

Binani Zinc Ltd. also produced cadmium at its zinc plant in Binanipuram. Production capacity was 65 t/yr of refined cadmium (Metal Bulletin, 2009a).

Korea, Republic of.—Korea Zinc (Seoul, Republic of Korea) was one of the leading suppliers of cadmium metal to China. Production capacity of refined cadmium at the company's leading smelter, the Onsan zinc-lead refinery in Kyoung Nam Province, was approximately 3,000 t/yr. From August until December, Onsan ran at reduced capacity as Korea Zinc carried out repairs at the zinc smelter. As a result, the company said it was no longer able to offer cadmium on the spot market, as cadmium production rates were reduced by 50%. During this period, the company produced 15 metric tons per month (t/mo) of cadmium, compared with the normal 20 to 30 t/mo (Metal Bulletin, 2009b).

Cadmium was also produced at Young Poong Corp.'s (Seoul) Sukpo zinc refinery in the form of sticks. Cadmium production capacity at Sukpo was 805 t/yr. During the last half of the year, cadmium production was reduced to 20 to 30 t/mo from the normal 50 to 60 t/mo while the facility underwent an expansion to increase cadmium production capacity to 1,400 t/yr (Metal Bulletin, 2010).

Mexico.—Refined cadmium in Mexico was produced mainly at Industrias Peñoles S.A. de C.V.'s Met-Mex metallurgical complex in Torreon (in the form of balls and sticks) and at Grupo Mexico S.A. de C.V.'s electrolytic zinc refinery in San Luis Potosi (in the form of ingots, mini-jumbos, spheres, and sticks). Cadmium-bearing zinc concentrates treated at San Luis Potosi were sourced from Grupo Mexico's mines, principally the Charcas zinc mine. About 60% of the zinc concentrates processed at Met-Mex originated from Industrias Penoles' mines.

Peru.—Cadmium metal was produced at Votorantim's Cajamarquilla zinc refinery and at Doe Run Peru's (Lima) La Oroya metallurgical operations. Cajamarquilla had the capacity to produce 430 t/yr of cadmium.

Poland.—Zinc metal producer Huta Cynku Miasteczko Slaskie has been producing cadmium since mid-2000 and was the only cadmium producer in Poland. In 2008, the company began processing secondary materials—including Waelz oxides and EAF dust—along with zinc concentrates to reduce costs. Huta Cynku ultimately planned to completely switch its feedstock to secondary materials by 2010. Cadmium can be recovered from EAF dust (Leahy, 2008).

Russia.—Cadmium metal in Russia was produced at Chelyabinsk Zinc Plant OJSC's (Chelyabinsk) zinc refinery and Ural Mining and Metallurgy Company's (Sverdlovsk) Electrozinc lead-zinc refinery. Chelyabinsk's cadmium production decreased by 7% in 2009 from that of 2008 to 551 t (Chelyabinsk Zinc Plant OJSC, 2010, p. 13).

Outlook

Concern over cadmium's toxicity has spurred various legislative efforts, especially in the European Union, to restrict the use of cadmium in most of its end-use applications. However, cadmium-containing residues will continue to be produced as a byproduct from the zinc smelting process, regardless of cadmium demand. If the applications and markets for cadmium continue to decline, excess byproduct cadmium may need to be permanently stockpiled and managed, similar to the situation that the U.S. Government now faces with mercury.

However, demand for cadmium may increase owing to several new market opportunities for NiCd batteries, particularly in industrial applications. NiCd batteries power some battery electric vehicles in circulation and are also used as a source of power in a limited number of hybrid electric vehicles. NiCd batteries have also been used to support various renewable energy installations owing to their long service life, low maintenance, and stability in harsh weather environments. NiCd batteries were also used as a buffer in transportable, renewable hybrid-power systems developed to generate electricity in remote locations and underdeveloped regions.

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TABLE 1

SALIENT CADMIUM STATISTICS[1, 2]

		2005	2006	2007	2008	2009
United States:						
Production of metal[3, 4]	metric tons	1,470	723	735	777	633
Shipments of metal by producers[4, 5]	do.	1,680	833	692	774	737
Exports of metal, alloys, scrap	do.	686	483	424	421	661
Imports for consumption, metal, alloys, and scrap	do.	288	180	316	197	122
Apparent consumption of metal	do.	2,060 r	530 r	594 r	528 r	199
Price, average, New York dealer[6]	dollars per pound	1.50	1.35	3.45	2.69	1.30
Do.[6]	dollars per kilogram	3.30	2.98	7.61	5.92	2.87
World, refinery production	metric tons	20,100	19,900	19,400	20,100 r	18,800 e

e Estimated. r Revised. Do., do. Ditto.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Cadmium content.

[3] Primary and secondary cadmium metal. Includes equivalent metal content of cadmium sponge used directly in production of compounds.

[4] Partially estimated.

[5] Includes metal consumed at producer plants to make oxide and other cadmium compounds.

[6] Price for 1- to 5-short ton lots of metal having a minimum purity of 99.95% (Platts Metals Week).

TABLE 2

SUPPLY AND APPARENT CONSUMPTION OF CADMIUM METAL[1, 2]

(Metric tons)

	2005	2006	2007	2008	2009
Producer stocks, January 1[3]	1,170	184 r	74 r	107 r	132
Production[3]	1,470	723	735	777	633
Imports for consumption, metal, alloys, and scrap	288	180	316	197	122
Total supply	2,930	1,090 r	1,130 r	1,100 r	887
Exports of metal, alloys, scrap	686	483	424	421	661
Producer stocks, December 31[3]	184 r	74 r	107 r	132 r	27
Consumption, apparent[4]	2,060 r	530 r	594 r	528 r	199

r Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes supply and apparent consumption of cadmium sulfide, cadmium telluride, and related cadmium chemicals.

[3] Partially estimated. Beginning stocks may not equal ending stocks of the prior year owing to inventory adjustments.

[4] Total supply minus exports and yearend stocks.

TABLE 3
U.S. EXPORTS OF CADMIUM PRODUCTS, BY COUNTRY AND TYPE[1]

	2008		2009	
	Quantity (kilograms)	Value	Quantity (kilograms)	Value
Cadmium (Cd) metal:[2]				
Belgium	--	--	900	$18,100
Canada	48,500	$270,000	22,300	129,000
China	314,000	1,350,000	335,000	823,000
Colombia	2,390	26,100	--	--
Denmark	4,120	10,000	--	--
Germany	3,310	174,000	29,700	443,000
Israel	35,300	212,000	17,000	69,300
Korea, Republic of	21	7,010	76,900	274,000
Netherlands	--	--	17,000	161,000
Singapore	6,450	58,700	--	--
United Kingdom	5,950	97,700	3,380	22,600
Other	1,140 r	69,300 r	159,000	185,000
Total	421,000	2,270,000	661,000	2,120,000
Of which:				
Unwrought and powder	295,000	1,370,000	276,000	1,270,000
Waste and scrap	--	--	137,000	319,000
Other	126,000	901,000	249,000	537,000
Cadmium sulfide, gross weight:				
Hong Kong	5,000	2,600	--	--
India	16,500	8,590	--	--
Italy	24,500	12,800	--	--
Malaysia	171,000	89,000	--	--
Mexico	10,900	5,670	--	--
Switzerland	--	--	5,640	2,940
United Kingdom	13,200	6,860	10,600	5,510
Total	241,000	125,000	16,200	8,440
Total, calculated Cd content	188,000	XX	12,600	XX
Cadmium pigments:				
Brazil	16,300	68,200	11,300	52,300
Canada	73,700	1,280,000	116,000	1,820,000
China	16,400	46,400	13,600	44,500
Colombia	33,200	139,000	5,840	44,100
Dominican Republic	138,000	215,000	6,180	41,600
Ecuador	128,000	264,000	--	--
Germany	47,500	202,000	3,260	44,100
Guatemala	77,000	126,000	96,300	156,000
Hong Kong	4,490	40,300	24,600	42,200
Jamaica	57,300	116,000	58,800	99,600
Mexico	458,000	2,230,000	904,000	3,580,000
Morocco	17,000	24,700	--	--
New Zealand	17,000	25,400	--	--
Switzerland	15,000	885,000	10,800	1,090,000
Turkey	3,410	110,000	--	--
United Kingdom	2,770	127,000	211	4,480
Other	86,700	342,000	88,900	345,000
Total	1,190,000	6,240,000	1,340,000	7,360,000

r Revised. XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes exports of cadmium in alloys (Schedule B 8107.90) and waste and scrap (Schedule B 8107.30).

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS OF CADMIUM PRODUCTS, BY COUNTRY AND TYPE[1]

	2008		2009	
	Quantity (kilograms)	Value	Quantity (kilograms)	Value
Cadmium (Cd) metal:[2]				
Australia	51,000	$368,000	38,000	$121,000
Belgium	17,200	449,000	14,800	301,000
Canada	63,400	4,220,000	21,700	576,000
China	--	--	4,020	109,000
France	33	25,400	--	--
Germany	68	7,990	4,040	38,200
India	10	5,000	--	--
Japan	14	29,200	3	3,210
Malaysia	66	12,200	--	--
Mexico	40,000	312,000	11,500	25,500
Peru	25,000	194,000	24,000	63,000
Russia	2	18,000	--	--
Singapore	5	8,250	--	--
United Kingdom	--	--	3,960	247,000
Total	197,000	5,650,000	122,000	1,480,000
Of which:				
Unwrought and powder	153,000	5,090,000	117,000	1,110,000
Other	44,000	565,000	4,940	371,000
Cadmium oxide:				
Belgium	88,800	940,000	115,000	760,000
India	16,000	138,000	--	--
Japan	320	24,100	240	19,800
Netherlands	--	--	5,230	50,000
United Kingdom	7	5,870	25	2,200
Total	105,000	1,110,000	120,000	833,000
Total, calculated Cd content	92,000	XX	105,000	XX
Cadmium sulfide, gross weight:				
Canada	40,800	220,000	55,900	446,000
China	318,000	315,000	--	--
Germany	8	2,440	--	--
Russia	77,800	2,470,000	74,000	1,960,000
United Kingdom	1,820	35,100	4,720	21,200
Total	439,000	3,040,000	135,000	2,420,000
Total, calculated Cd content	341,000	XX	105,000	XX
Cadmium pigments:				
Belgium	10,900	188,000	750	11,100
Brazil	6,020	96,700	1,990	51,300
Canada	8,410	77,000	2,770	36,500
China	--	--	2,000	8,800
Finland	5,410	136,000	--	--
France	4,850	90,100	--	--
Germany	25,600	167,000	62,900	414,000
India	--	--	3	7,560
Japan	--	--	487	42,200
Mexico	241	3,590	--	--
Netherlands	45	2,820	--	--
Taiwan	500	3,080	--	--
United Kingdom	110,000	1,730,000	58,900	1,050,000
Total	172,000	2,500,000	130,000	1,630,000

See footnotes at end of table.

TABLE 4—Continued
U.S. IMPORTS OF CADMIUM PRODUCTS, BY COUNTRY AND TYPE[1]

XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes imports of other cadmium [Harmonized Tariff Schedule of the United States (HTS) 8107.90.00] and waste and scrap (HTS 8107.30.00).

Source: U.S. Census Bureau.

TABLE 5
CADMIUM: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Argentina	3	6	35 [r]	38 [r]	30
Australia	358	329	351	330	300
Brazil[4]	200	141	200 [e]	200 [e]	200
Bulgaria	319	363	459	460 [e]	460
Canada[5]	1,727	2,090	1,388	1,409 [r]	1,299 [p, 6]
China[e]	4,080	3,790	4,210	4,300	4,300
Germany[e]	640	640	400	400	400
India	409	457	583	599	610
Italy[e]	10	10	10	10	10
Japan	2,297	2,287	1,933	2,116	2,200
Kazakhstan	2,000	2,000	2,100	2,100 [e]	1,800
Korea, North[e]	200	200	200	200	200
Korea, Republic of	2,582	3,320	2,846	3,090 [r]	3,000
Mexico[7]	1,653	1,401	1,617	1,550 [r]	1,210
Netherlands	494	524	495	530	530
Norway	153	125	269	178	175
Peru	481	416	347	371	375
Poland	408	373	421	603 [r]	600
Russia	621	690	810	800	700
Ukraine[e]	25	25	25	25	25
United States[5]	1,470	723	735	777	633 [6]
Total	20,100	19,900	19,400	20,100 [r]	18,800

[e] Estimated. [p] Preliminary. [r] Revised.

[1] This table gives unwrought production from ores, concentrates, flue dusts, and other materials of both domestic and imported origin. Sources generally do not indicate if secondary metal (recovered from scrap) is included or not, where known, this has been indicated by a footnote. Data derived in part from World Metal Statistics (published by World Bureau of Statistics, Ware, United Kingdom) and from Metal Statistics (published jointly by Metallgesellschaft AG of Frankfurt am Main, Germany, and World Bureau of Metal Statistics). Cadmium is found in ores, concentrates, and (or) flue dusts in several other countries, but these materials are exported for treatment elsewhere to recover cadmium metal; therefore, such output is not reported in this table to avoid double counting. This table includes data available through May 6, 2010.

[2] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[3] Romania, Thailand, and Uzbekistan may produce primary cadmium metal or oxide, but information is inadequate to make reliable estimates of output.

[4] Data for 2005 are exports from Anuario Mineral Brasileiro (Departmento Nacional de Producao Mineral).

[5] Includes secondary.

[6] Reported figure.

[7] Excludes significant production of both cadmium oxide and cadmium contained in exported concentrates.

CEMENT

By Hendrik G. van Oss

Domestic survey tables were prepared by Michelle B. Blackwell, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

Combined production of portland and masonry cement in the United States in 2009 was 63.9 million metric tons (Mt). This was a 25.9% decline from production in 2008, a 35.6% decrease from the record output in 2005 (table 1), and the lowest level of output since 1983. Consumption of portland and masonry cement as measured by sales to domestic final customers decreased in 2009 by 26.7% to 71.0 Mt (table 9), also the lowest level since 1983 and nearly 57 Mt or 44.5% lower than the 2005 record. In contrast, the decline in sales prices (mill net valuation basis) in 2009 was comparatively modest (tables 1, 11–13). Overall, the value of cement sales totaled $7.0 billion, down by about 30% from that of 2008. Based on typical portland cement mixing ratios in concrete, the delivered value of concrete (excluding mortar) in the United States was estimated to be at least $47 billion in 2009.

Percentage or other changes expressed in this report compare activity in 2009 with that of 2008 unless specified otherwise. Except where otherwise indicated, activity levels in this report exclude those in Puerto Rico. Cements covered in this report are mainly limited to those hydraulic varieties broadly classified as portland cement (including blended cement and other varieties listed in table 15) and (or) masonry cement (including portland-lime and plastic cements); these are the binding agents in concrete and most mortars. A few other types of hydraulic cements and (or) clinker (notably aluminous cement) are included in some of the trade data (tables 16–18 and 21) and within the world production data (table 22). Except where incorporated as components within finished portland (blended) or masonry cements, this report's tables exclude supplementary cementitious materials (SCM), such as fly ash, other pozzolans, and ground granulated blast furnace slag (GGBFS). Sales data for blended (also called composite) cements listed separately from portland cement are available in the monthly Mineral Industry Surveys reports of the U.S. Geological Survey (USGS).

The bulk of this report is based on data compiled from USGS annual questionnaires sent to cement and clinker manufacturing plants and associated distribution facilities and import terminals, and some terminals that are independent of U.S. cement manufacturers. For 2009, questionnaires were received from 152 of 156 facilities canvassed, a response rate of 97%, which included all of the production sites. For 2008, questionnaires were received from 149 of 152 facilities canvassed, a response rate of 98%, including all of the production sites. If missing data could not be obtained by followup telephone inquiries, they were estimated based on monthly data or past annual reporting. For both years, the data exclude several importers that have yet to participate in the surveys. To the degree that they are independent of the participating companies, sales by the missing importers for 2008 and 2009 are estimated to be equivalent to an additional 1% of the total portland cement sales tonnages shown in this report. Background information on cement and its manufacture and on the USGS cement canvasses can be found in van Oss (2005).

Government Programs and Environmental Issues

A number of ongoing Government programs provide funding and direction for public sector construction and were thus of importance to cement consumption levels. In 2009, stimulus program spending allotments, including those related to the American Recovery and Reinvestment Act (ARRA) of 2009, were being compared to individual State spending of the appropriated monies as a means to predict increases in cement demand. By late 2009, it was evident that very little of the stimulus spending during the year had been for cement (concrete) but it was anticipated that the concrete industry would significantly benefit from ARRA funding in 2010 (Sullivan, 2010).

Environmental issues associated with the cement industry mostly result from the manufacture of the intermediate product called clinker. In clinker manufacture, the burning of large amounts of raw materials and fuels leads to significant emissions of carbon dioxide (CO_2), and can yield significant emissions of nitrogen oxides (NOx), sulfur oxides (SOx), mercury and some other metals, volatile organic carbon compounds, and particulates. Increasingly, these emissions are regulated or are being considered for regulation or reregulation. The largest volume emissions are of CO_2; the cement industry is one of the leading industrial emitters of this greenhouse gas (GHG). Overall, generation of CO_2 by the U.S. cement industry in 2009 was calculated to be in the range of 0.87 to 0.92 metric ton (t) of CO_2 per ton of clinker produced; the high end incorporates fuel combustion emissions calculated using "standard" heat values for the fuels consumed (table 7), and the low end incorporates heat values actually reported by the individual plants. Both ratios include a standard emissions factor from calcination of limestone of 0.51 t of CO_2 per ton of clinker as detailed by the Intergovernmental Panel on Climate Change (Hanle and others, 2006), but exclude any correction for cement kiln dust (CKD) not recycled to the kiln (for which data are lacking). However, the standard calcination component of CO_2 emissions can be reduced in the calculation in proportion to the calcium oxide contributed by noncarbonate alternative raw materials such as ferrous slags and coal combustion ashes. This incorporation would allow a reduction of calcination-related emissions of about 2.4% (0.7 Mt of CO_2) in 2009 and 2.7% (nearly 1.1 Mt of CO_2) in 2008; relative reductions can be significantly larger for the subset of individual plants that actually burn these alternative raw materials. Certain fuels, including alternative or waste fuels, can either directly reduce plant-level CO_2 emissions or may lead to reductions in reported emissions from combustion because the fuels are considered to be carbon-neutral (certain biofuels) or because credits may be allowed for their use (certain waste fuels). Plant-level emissions can be reduced through upgrading to more fuel-efficient kiln line technology. Unit emissions can also be reduced by use of SCM in finished cement and in concrete to reduce the clinker content of these products and (or) by allowing the addition of "inert" fillers to boost cement output without simultaneously boosting clinker output.

In past years, the U.S. Environmental Protection Agency (EPA) used methods similar to those used above to calculate and report overall U.S. levels of GHG emissions by various industries; for cement, these methods made use of national-level clinker production data published by the USGS. However, to more accurately determine U.S. emissions of GHG, in October, the EPA released a final rule for mandatory site/plant-specific reporting of GHG emissions (to begin in 2010) (U.S. Environmental Protection Agency, 2009b). For the cement industry's CO_2 emissions, relevant calculation procedures for fuel combustion are covered under Part 98, subpart C (p. 56397–56411) and, for calcination and related process emissions, in subpart H (p. 56420–56422).

In May, the EPA proposed new, very low, limits on individual plant emissions of mercury, total hydrocarbons, particulate matter, and hydrochloric acid within a set of national emissions standards for hazardous air pollutants (NESHAP) for the U.S. cement industry (U.S. Environmental Protection Agency, 2009a). It was unclear how many U.S. cement plants would be able to comply with the new NESHAP limits for all four listed pollutants. The new standards for mercury were set so stringent (for existing plants, 43 pounds of mercury per million short tons of clinker produced; and for new plants, 14 pounds of mercury per million short tons of clinker produced) as to possibly preclude, absent the installation of mercury scrubbers, which could be very expensive, the use at many plants of their normal raw materials and of coal as a fuel. The NESHAP could end the use of fly ash as an alternative raw material for clinker manufacture; fly ash commonly has a high mercury content and this content was expected to increase as coal-fired powerplants installed their own scrubbers. The mercury-scrubbing technology most commonly discussed makes use of activated carbon, and this mercury-laden carbon (at a powerplant) would report to the fly ash. A discussion of the cement NESHAP is provided by O'Hare (2009).

The EPA was evaluating changing the regulatory classification of coal combustion byproducts, particularly fly ash, under conditions of long-term or permanent storage (disposal) and for various usage purposes. Concern in the construction sector was that if fly ash were to be reclassified as a hazardous waste, even under restricted circumstances, the material would be stigmatized and demand for it would decrease or cease altogether (Goss, 2010).

Production

Continued declining sales of cement, together with an apparent drawdown of cement stockpiles, and despite a major decline in cement imports, led to a 25.6% decrease in portland cement production in 2009 to just 62.0 Mt (table 3). This was the lowest production since 1983 and was nearly 32 Mt less than the record output in 2005. Production fell in all districts except Indiana. Yearend stocks of portland cement fell by 28%. Owing to two plants coming online during the year (Florida and Missouri) and of some new mills at existing plants, overall grinding capacity increased by about 6%. The capacities and plant counts listed in table 3 for 2009 are, however, somewhat uncertain because of difficulties differentiating between plants reported as "idle" (or "indefinitely idle") and those that were permanently "closed." At least in terms of sales, some such plants continued to operate as distribution terminals. Likewise, plants that closed their kilns in late 2008 may have continued to grind remaining clinker stocks until they were exhausted in early 2009 after which the finish mills were closed as well. The USGS policy has been to count as active all plants having production for at least 1 day during the year, but this policy may not be realistic for plants idle all year and which offered few prospects of ever reopening. Thus, in a few locations, a decision was made for the 2009 tally to exclude plants that were "idle" throughout 2009–10 and for which a formal closure announcement was made in 2010. In one district, an ultimately closed plant was retained in the 2009 count because it made a small quantity of masonry cement early in the year, thus still having active grinding capacity. Another plant, seemingly closed, retained the possibility of restarting its finish mill. One plant in Florida that had been announced as closed in late 2008 was retained in the 2009 count despite no production during the year because its status was confirmed as idled, rather than closed.

For masonry cement, a stagnant housing construction sector during the year led to a decline in cement production of 35% to just 2.0 Mt, the lowest level since at least 1954.

With common parents combined under the larger subsidiary's name and with joint ventures apportioned, the 10 leading companies at yearend 2009, in descending order of portland cement production, were Holcim (US) Inc., CEMEX, Inc., Lafarge North America Inc., Lehigh Cement Co., Buzzi Unicem USA Inc. (including Alamo Cement Co.), Ash Grove Cement Co., Texas Industries, Inc. (TXI), Essroc Cement Corp., CalPortland Co., and St. Marys Cement Inc. The listing was unchanged from that of 2008. The U.S. industry continued to be heavily consolidated—the leading 5 cement companies, combined, contributed 59% of total U.S. portland cement production, and the leading 10 companies accounted for 81% of total production. Of the above named companies, all except Ash Grove and TXI were foreign owned as of yearend, and for the industry overall, about 77% of total cement output was by foreign-owned companies.

Clinker output in 2009 fell by 28.4% to 56.1 Mt (tables 1, 5). This was the lowest level since 1982. Production fell in all months, and for the year overall in all districts. Owing to a new plant coming online, the commencement of production from a plant that was completed at yearend 2008, and upgrades at some existing plants, apparent annual capacity increased by 6.5%; this was despite the removal in the 2009 total of plants or kilns closed during 2008. Utilization of clinker production capacity was only about 49% in 2009, well down from the 73% of the previous year and the presumed "full practicable" capacity utilization of 85% or more experienced during years of high cement sales volumes. The performance in 2009 reflected a combination of permanent kiln or plant closures and long-term idling of "extra" kilns at multikiln plants. However, the utilization statistic is dependent on the reported downtime for routine maintenance. Many plants reported much longer than normal downtimes for this purpose in 2009; where this was obvious, corrections were made after consultation with the plants to remove the extra downtime (a result of slow sales) from the statistic. Yearend clinker stockpiles decreased by nearly 30%, likely reflecting yet more kiln idlings late in the year.

Nonfuel raw materials consumed to make clinker and cement are listed in table 6. Ratios among clinker raw materials consumed in 2009 appear to be broadly similar to those in 2008. For fly ash and bottom ash, the data are similar to those published by the American Coal Ash Association (ACAA) for sales for use in making clinker and cement (combined), namely 2.210 Mt of fly ash and 0.654 Mt of bottom ash (American Coal Ash Association, 2010; Goss, 2010). The ACAA also noted sales of 0.382 Mt of synthetic gypsum to the cement industry; this is less than the 0.47 Mt or more of this material included within the "Gypsum and anhydrite" data in table 6, but could reflect the fact that the ACAA does not survey the cement plants' own manufacture of this material.

Data on fuel consumption by the cement industry are listed in table 7. Data shifts can reflect activities at just a few plants. In terms of overall mass ratios among fuels in total and relative to clinker production, significant changes in 2009 were evident for several fuels but in part reflected closure and full-year idling of several wet kilns and some less efficient long dry kilns during the year. A much smaller percentage of clinker was contributed by wet kilns in 2009, for example. The significant increase in the consumption of natural gas reflects a combination of the incorporation of large amounts of landfill gas at two plants, and a shift from gas as a warm up fuel to a major use fuel reported at two facilities. Some of the other apparent shifts reflect upgrades, including conversions from wet to dry kiln technology at some plants.

Although not revealed in table 7, overall heat consumption (gross heat basis) in 2009 was about 3.9 billion joules (GJ) per metric ton of clinker, down by about 9% from that in 2008. The reduction reflected the closure or idling of wet kilns and less efficient dry kilns during the year. Heat energy consumption at the remaining operational wet kilns averaged 6.0 GJ per ton of clinker, down by nearly 8%. Dry kilns averaged 3.6 GJ per ton of clinker, down by 10%. Thus, efficiency apparently improved despite much longer and perhaps more frequent than normal total downtimes (for all reasons) on the operational kilns. It is possible that further reductions in unit energy consumption will be realized if and when the industry resumes more normal operating schedules. As in past years, coal supplied the largest share of the heat consumed (60%, down by about 7%), followed by petroleum coke (about 21%, unchanged), and waste fuels (13%, up by 22%). As noted above, natural gas, including landfill gas, use increased markedly; it contributed about 5% of total heat in 2009, up by 74%.

The average unit electricity consumption increased again in 2009 (table 8); this most likely reflects operational disruptions (idlings and closures, repairs, plant upgrades) at many plants, and a greater reliance on dry plants. Dry plants, commonly, have higher unit electricity consumption than do wet plants.

There were no significant ownership changes in the U.S. cement industry in 2009. Two new plants were brought into production during the year. American Cement Co., LLC began operations early in the year at its 1.0-million-metric-ton-per-year (Mt/yr) plant at Sumterville, FL; plant construction had been completed at yearend 2008. Initial cement production was from purchased clinker, but the plant started its own clinker production in May. American Cement was a joint venture between Oldcastle Materials, Inc. and New Jersey-based Trap Rock Industries, Inc. In July, Holcim fired the 4.0-Mt/yr precalciner kiln at its new plant in St. Genevieve County, MO; this kiln was said to have the largest annual capacity of any in the world and was expected, at full output levels, to put Missouri at or near the forefront of U.S. clinker production.

The litany of plant closures and long-term or indefinite idlings of plants that began in 2008 continued in 2009, although many of the facilities continued to operate as storage, packaging, and transshipment terminals for cement sourced elsewhere. At the end of January, Ash Grove indefinitely idled the wet kilns at its Inkom, ID, plant, but the facility continued to produce cement from clinker stockpiles and from clinker brought in from another Ash Grove plant. CalPortland idled the long dry kilns at its Colton, CA, plant during the course of the year but continued to make cement from clinker brought in from the company's Mojave, CA, facility. CEMEX confirmed that its Brooksville "North" plant in Florida was on indefinite idle status in 2009, and had not been closed as had been reported in 2008. Essroc closed the wet kilns at its Bessemer, PA, plant at the end of April and shut the finish mill there at the end of September. At the end of April, Holcim shut its wet plants at Dundee, MI, and Clarksville, MO; the Clarksville plant's kiln was the longest in the world. At the same time, the company indefinitely idled its wet plant at Artesia, MS, and in September, indefinitely idled its dry plant at Mason City, IA. In addition to these plant closures and (or) indefinite idlings, many multikiln plants had one or more kilns idle for all or part of the year.

Major kiln line upgrades were completed at three cement plants in 2009. In August, Buzzi Unicem fired the new 1.2 Mt/yr precalciner kiln at its River (also known as the Festus or Selma plant), at Festus, MO; the new kiln replaced the existing pair of long dry kilns (Buzzi Unicem, 2009). Also in November, Keystone Cement Co. fired its new precalciner kiln line at Bath, PA; the new 1.2-Mt/yr line replaced the plant's pair of wet kilns, which were shut down at the same time. In August, Essroc closed the three wet kilns at its Martinsburg, WV, plant and in November fired the plant's new 2.0-Mt/yr precalciner kiln that had been under construction.

Some ongoing upgrade projects were cancelled or postponed in light of poor cement sales. An example was the January announcement by TXI that it was postponing further work on the expansion project at its cement plant at Hunter, TX (Texas Industries, 2009); the project was expected to resume once market conditions improved.

Consumption

Cement consumption data for the United States were surveyed and reported monthly by the USGS in terms of sales to final customers and are summarized in table 9. Although the national sales totals in table 9 are similar to the shipments totals in tables 11, 12, and 14, only the table 9 breakout tonnages represent State-level consumption. The regional breakouts in tables 11, 12, and 14 simply pertain to the locations of the reporting entities (chiefly the production sites), not the locations of consumption. It is very common for shipments to cross State lines.

The U.S. cement market in 2009 continued a decline that began in early to mid-2006; this reflected ongoing stagnation in several construction sectors, particularly in housing, a tight loan market, and continued declines in State property tax revenues. Decreases in sales of cement were experienced in all months during the year. Total sales of portland cement to domestic final customers fell by 26.5% to 68.9 Mt, the lowest level since 1983. Sales declined in all districts; those into the three traditionally leading consuming States (California, Florida, and Texas) were down by about 32% in 2009. Although sensitive to the accuracy of the population data, per capita consumption of portland cement was just 220 kg in 2009, the lowest level since 1947; the amount in 2008 was 413 kg. Masonry cement consumption decreased by 31.0% to 2.1 Mt, the lowest level since 1949.

Sales by some importers that did not participate in the USGS monthly and annual surveys were not included in the portland cement consumption data in this report. An estimate of these missing importers' sales can be made by comparing official (U.S. Census Bureau) trade data (tables 17, 21) with the import origins of sales (table 9). The official cement imports were about 0.3 Mt higher than the foreign origin tonnages in 2009 and 1.5 Mt higher than those in 2008; however, the discrepancy in 2009 appears to be too small based on known missing data for cement from the Republic of Korea into the Philadelphia, PA, customs district (0.139 Mt), and of much of the material from Colombia into the Houston, TX, and Wilmington, NC, districts (0.369 Mt). It appears that part of the reason for the difference in 2009 is that the table 9 import origins of sales data include a large component of drawdown of stocks, as suggested by the large yearend stockpile decline for importers listed in table 3. Adjusting for both years for cement varieties that are in the trade tables but not covered by the USGS canvasses (chiefly aluminous cement) and for apparent drawdown of stocks, which cannot fully distinguish between imported and domestic cement, it becomes evident that the annual tables are missing about 0.5 Mt of cement sales in 2009 and about 1 Mt in 2008.

As the binder in concrete, cement consumption levels within a given category of construction will broadly reflect levels of construction spending, although significant time lags may exist between the onset or cutoff of spending and changes in the consumption of cement. In terms of 1996 constant dollars, overall construction spending in 2009 fell by 15% to $552 billion (Portland Cement Association, 2011). Within this spending, public sector construction was the largest share, at $184 billion, down by 0.8% only. Residential construction, which had been the dominant sector in 2008, fell in 2009 by 25% to $168 billion. Nonresidential construction spending was $133 billion, down by 21%.

Portland cement sales broken out by customer type are listed in table 14. Sales to ready-mixed concrete producers accounted for about 71% of total shipments, but the true tonnage for this type of concrete was larger because some of it was recorded under other customer categories, such as road paving contractors. As listed, the sales to ready-mixed customers declined by 27%, in line with the decrease in overall portland cement sales. The decline in residential construction spending noted above is in line with the 34% decline in sales tonnages of cement for brick and block; and the decline in nonresidential private and public sector spending noted is in line with reduced sales of cement for precast–prestressed concrete products (down by 28%), and for road paving (down by 22%). Sales of cement for oil well and gas well drilling fell by 45%, in line with sharply reduced oil and gas prices and drilling activities in 2009.

Sales of different types of portland cement are broken out in table 15. As in past years, sales were dominated by Types I and II cements and sulfate-resistant varieties of cement (Type V and Type II/V hybrids reported as Type V). Sales of these cements fell more or less proportionately to overall portland cement sales. Oil well cement sales fell by 42%, a result similar to that in table 14 noted above. White cement sales fell by 30%. As in past years, the white cement sales tonnage was significantly less than the imports of white cement (table 20) and would seemingly preclude any need for domestic production of the material. The discrepancy is partly explained by the use of some imported white cement for masonry cement (sales not included in table 15), and by the fact that some imported white cement is blended with domestically produced white cement.

Blended cement sales in table 15 fell by about 34% to 1.3 Mt, but this tonnage is significantly less than the blended cement sales reported for 2009 in the monthly reports of the USGS (1.6 Mt). It is unclear why this difference exists, except that there could be inconsistent reporting between the monthly and annual surveys of cement sold under the general performance standard ASTM C–1157, which at one time applied only to blended cements but which now applies to hydraulic cements in general.

Data on the mill net values for shipments to final customers by plants and import terminals (terminal nets) are provided in tables 11 to 13. Despite the large drop in sales tonnages, unit prices for portland and masonry cement declined relatively modestly.

Foreign Trade

Trade data from the U.S. Census Bureau are presented in tables 16–21. Although at the highest tonnage level since 1948, exports of cement and clinker continued to be small compared with imports. Canada remained by far the dominant destination of the exports, taking about 76% of the total in 2009.

Total imports of cement and clinker in 2009 fell by 40.5% to 6.8 Mt (table 17), the lowest total since 1992 and a decline of 28.8 Mt from the record level of 2006. The dominant share of imports was gray portland cement, imports of which fell by nearly 44% to 5.4 Mt (table 19). Canada continued to be the dominant source of U.S. imports. The tonnage of portland cement imported from Canada in 2009 fell by nearly 20%, but this was a small relative decline compared with those of most other countries. The relative regional sourcing of imports has changed dramatically in recent years. For example, Canada's share of the U.S. cement and clinker import market was 50% in 2009, much higher than the 14% share it held in 2006. By comparison, Asia, which had accounted for 19.5 Mt or 54% of total imports in 2006, supplied just 1.8 Mt or 26% of the imports in 2009. China alone supplied nearly 30% of total U.S. imports in 2006 but accounted for only 9% of the imports in 2009.

Official imports of clinker fell by 10.5% to 0.56 Mt (table 21). The clinker data are incomplete, however, with regard to overland imports from Canada; the tonnages listed are insufficient to have fully supplied the grinding plants in Michigan and Washington, all of which imported their clinker from Canada. The unreported Canadian clinker appeared mostly to be coming in by truck, at a value of less than $2,000 (customs value) per truckload; such shipments are classified as "informal entries" and data on them are not routinely transmitted by the U.S. Customs Service to the U.S. Census Bureau for recordation into the official trade data (reproduced in tables 17–21). This problem presumably does not exist for imports by rail or by ship because these shipments are larger. Clinker imports from Canada were estimated to be higher than those reported in tables 1 and 21 by about 0.7 Mt in 2008 and by about 0.2 Mt in 2009.

With the decline in imports, especially from Asia, several of the once-busiest import locations have fallen from prominence, and overland import locations have become relatively dominant. For cement and clinker combined, the 10 busiest customs districts of entry in 2009 were, in descending order of tonnage, Detroit, MI; Houston-Galveston, TX; Seattle, WA; Buffalo, NY; Cleveland, OH; Columbia-Snake, OR and WA; Honolulu, HI; El Paso, TX; Ogdensburg, NY; and Savannah, GA (table 18). These leading districts accounted for about 71% of the total imports for the year.

World Review

World hydraulic cement production data are listed in table 22. The data are intended to include all forms of hydraulic cement; however, the data for the United States are for portland and masonry cement only, and data for some other countries also may be incomplete. For some countries, the production data may include exports of clinker.

World cement output in 2009 was an estimated 3.04 billion metric tons (Gt), up by 6.7%. Production was from more than 150 countries. China was again the world's leading producer by far, with an output of 1.63 Gt or nearly 54% of the world total. The remaining top 20 producers were, in descending order of tonnage, India, the United States, Japan, Turkey, Brazil, the Republic of Korea, Iran, Vietnam, Egypt, Russia, Indonesia and Saudi Arabia (tied), Italy, Mexico, Pakistan, Thailand, Germany, Spain, and Malaysia. Cumulatively, the top 5 countries had about 66% of total world output, the top 10 countries, about 74%, and the top 20 countries, about 85%.

Regionally, Asia and the Pacific contributed about 71% of world production, included 9 of the 20 leading producing countries, and continued to experience the greatest growth rate of all regions. The Middle East (including Turkey), had 6.8% of world output; Western Europe, 6.1%; Africa, 4.3%; Central America and South America, combined, 3.8%; North America (including Mexico), 3.7%; the Commonwealth of Independent States, 2.5%; and Eastern Europe, 1.5%.

Outlook

A modest increase in concrete construction in 2010 was expected, based on projected beneficial downstream effects of stimulus funding on the general economy and the housing construction sector in particular, and on expected access to ARRA funding. Relatively little ARRA funding had gone to public sector construction projects involving concrete in 2009 and many States still had significant fractions of their respective ARRA allotments as yet unspent at yearend 2009. However, low revenues to the States from property taxes were expected to continue to hamper State contributions to construction projects funded jointly by State governments and the Federal Government. It was recognized that a return to cement consumption levels approaching those of the peak 2005–06 period was many years away. Of great concern to the cement industry was the proposed portland cement NESHAP, which would impose very low, stringent, limits on mercury and certain other emissions by cement plants. The NESHAP would be difficult to comply with owing to high cost of emissions control equipment and potential problems of sufficient control equipment availability within the 3-year NESHAP compliance window. According to some industry analysts, a large number of plants—representing perhaps 25% of U.S. production capacity—might have to close as a result of the NESHAP, forcing the concrete industry to increasingly rely on imported cement. Further, should fly ash become stigmatized as a result of an EPA reclassification of it as a hazardous material, the construction sector might lose this material as an alternative raw material or SCM, and thus hamper efforts to reduce the GHG "footprint" associated with concrete construction.

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TABLE 1

SALIENT CEMENT STATISTICS FOR THE UNITED STATES[1, 2]

(Thousand metric tons unless otherwise specified)

		2005	2006	2007	2008	2009
Production:						
Cement[3]		99,319	98,167	95,464	86,310	63,929
Clinker		87,405	88,555	86,130	78,382	56,116
Shipments from mills and terminals:[3, 4, 5]						
Quantity		128,000	127,000	114,000	96,700	71,100
Value[6]	(thousands dollars)	11,700,000	12,900,000	11,900,000	9,990,000	7,020,000
Average value[6]	(dollars per metric ton)	91.00	101.50	104.00	103.50	99.00
Stocks, yearend:						
Cement		7,450	9,380	8,890	8,360	6,080
Clinker		3,520	5,370	6,550	7,070	5,130
Exports		766	723 [7]	886 [7]	823	884
Imports:[8]						
Cement		30,403	32,141	21,496	10,744	6,211
Clinker		2,858	3,425	972	621	556
Total[9]		33,261	35,566	22,468	11,365	6,767
Consumption, apparent[10]		128,250	127,660	116,550	96,760	71,530
World production[e, 11]		2,350,000	2,610,000	2,810,000	2,850,000 r	3,040,000

[e] Estimated. [r] Revised.

[1] Unless otherwise indicated, data are for portland (including blended) and masonry cements only. Even where presented unrounded, data are thought to be accurate to no more than three significant digits.

[2] Excludes Puerto Rico.

[3] Includes cement made from imported clinker.

[4] Includes imported cement.

[5] Shipments to final domestic customers. Data are from an annual survey of plants and terminals and may differ from the totals in table 9, which are based on consolidated monthly surveys from companies.

[6] Value free on board mill or independently reporting terminal.

[7] Official export data have been corrected to remove an apparent excess of aluminous cement from Laredo, TX, of 943,939 metric tons in 2006 and 653,255 metric tons in 2007.

[8] All forms of hydraulic cement or clinker.

[9] Data may not add to totals shown because of independent rounding.

[10] Production (including that from imported clinker) of cement plus imports of hydraulic cement minus exports of hydraulic cement minus the change in yearend cement stocks.

[11] Total hydraulic cement. May include clinker exports for some countries.

TABLE 2
COUNTY BASIS OF SUBDIVISION OF STATES IN CEMENT TABLES

State subdivision	Defining counties
California, northern	Alpine, Fresno, Kings, Madera, Mariposa, Monterey, Tulare, Tuolumne, and all counties farther north.
California, southern	Inyo, Kern, Mono, San Luis Obispo, and all counties farther south.
Illinois, metropolitan Chicago	Cook, DuPage, Kane, Kendall, Lake, McHenry, and Will Counties in Illinois.
Illinois, excluding Chicago	All counties other than those in metropolitan Chicago.
New York, eastern	Delaware, Franklin, Hamilton, Herkimer, Otsego, and all counties farther east and south, except those within Metropolitan New York.
New York, western	Broome, Chenango, Lewis, Madison, Oneida, St. Lawrence, and all counties farther west.
New York, metropolitan	New York City (Bronx, Kings, New York, Queens, and Richmond), Nassau, Rockland, Suffolk, and Westchester.
Pennsylvania, eastern	Adams, Cumberland, Juniata, Lycoming, Mifflin, Perry, Tioga, Union, and all counties farther east.
Pennsylvania, western	Centre, Clinton, Franklin, Huntingdon, Potter, and all counties farther west.
Texas, northern	Angelina, Bell, Concho, Crane, Culberson, El Paso, Falls, Houston, Hudspeth, Irion, Lampasas, Leon, Limestone, McCulloch, Reagan, Reeves, Sabine, San Augustine, San Saba, Tom Green, Trinity, Upton, Ward, and all counties farther north.
Texas, southern	Brazos, Burnet, Crockett, Jasper, Jeff Davis, Llano, Madison, Mason, Menard, Milam, Newton, Pecos, Polk, Robertson, San Jacinto, Schleicher, Tyler, Walker, Williamson, and all counties farther south.

TABLE 3
PORTLAND AND BLENDED CEMENT PRODUCTION, CAPACITY, AND STOCKS IN THE UNITED STATES, BY DISTRICT[1]

(Thousand metric tons unless otherwise specified)

	2008					2009				
District[2]	Number of plants	Production	Grinding capacity[3]	Percentage utilized[4]	Yearend stocks[5]	Number of plants	Production	Grinding capacity[3]	Percentage utilized[4]	Yearend stocks[5]
Maine and New York	5	3,061	4,204	72.8	234 [6]	5	2,118	4,341	48.8	219 [6]
Pennsylvania, eastern	7	3,826	5,140 [6]	74.5	285	7	3,064	5,420 [6]	56.5	247
Pennsylvania, western	3	1,327	1,805	73.5	140	3	678	1,805	37.6	103
Illinois	4	2,655	3,390	78.3	268	3	1,487	3,390	43.9	237
Indiana	4	2,587	3,653	70.8	237	4	2,685	3,740 [6]	71.7	188
Michigan	5	4,928	7,332	67.2	287	5	3,548	6,983	50.8	163
Ohio	2	762	1,166	65.4	64	2	550	1,166	47.2	25
Iowa, Nebraska, South Dakota	5	3,987	5,840 [6]	68.3	458	5	2,991	5,840 [6]	51.2	266
Kansas	4	2,396	3,230 [6]	74.2	247	3	1,669	2,940 [6]	56.8	166
Missouri	5	4,651	7,230	64.3	532	6	4,418	13,035	33.9	622
Florida[7]	7	4,979	7,301	68.2	389 [6]	7	3,145	7,610 [6]	41.3	260
Georgia, Maryland, Virginia, West Virginia	7	5,057	6,780 [6]	74.6	595 [6]	6	3,859	7,180 [6]	53.7	334
South Carolina	3	2,925	5,085	57.5	137 [6]	3	1,868	5,085	36.7	77
Alabama	5	4,635	7,074	65.5	242	5	3,416	7,292	46.8	231 [6]
Kentucky, Mississippi, Tennessee	4	3,045	3,702	82.3	282	4	1,958	3,702	52.9	147
Arkansas and Oklahoma	4	2,623	3,130 [6]	83.9	198	4	2,067	3,127	66.1	182
Texas, northern	6	6,303	7,618	82.7	1,324	6	3,833	7,580 [6]	50.5	609
Texas, southern	6	4,778	6,330 [6]	75.5	260 [6]	6	4,519	6,505	69.5	226 [6]
Arizona and New Mexico	3	2,097	3,116	67.3	102	3	1,464	3,116	47.0	91
Colorado and Wyoming	4	2,610	4,449	58.7	173	4	2,165	4,517	47.9	149
Idaho, Montana, Nevada, Utah	6	2,727	3,728	73.1	221 [6]	6	2,050	3,728	55.0	156
Alaska and Hawaii	--	--	--	--	82	--	--	--	--	55
California, northern	3	1,678	2,853	58.8	188	W [8]	W [8]	W [8]	W [8]	W [8]
California, southern	8	8,201	10,855	75.6	310 [6]	11 [8]	7,153 [8]	13,600 [6, 8]	52.7 [8]	417 [6, 8]
Oregon and Washington	4	1,443	2,435	59.3	248 [6]	4	1,254	2,435	51.4	275 [6]
Importers[9]	--	--	--	--	310 [6]	--	--	--	--	182 [6]
Total[10]	114	83,283	117,000 [6]	70.9	7,810 [6]	112	61,961	124,000 [6]	49.9	5,620 [6]
Puerto Rico	2	1,301	1,898	68.5	44	2	936	1,780	52.6	47 [6]
Grand total[10]	116	84,584	119,000 [6]	70.9	7,860 [6]	114	62,897	126,000 [6]	50.0	5,670 [6]

See footnotes at end of table.

TABLE 3—*Continued*

PORTLAND AND BLENDED CEMENT PRODUCTION, CAPACITY, AND STOCKS IN THE UNITED STATES, BY DISTRICT[1]

W Withheld to avoid disclosing company proprietary data; included in "Total." -- *Zero.*

[1] *Even where presented unrounded, data are thought to be accurate to no more than three significant digits. Includes data for white cement. Includes cement made from imported clinker.*

[2] *District assignation is the location of the reporting facilities. Specific districts include importers for which district assignations were possible.*

[3] *Grinding capacity is based on fineness needed to produce a plant's normal output mix, including masonry cement, and allowing for downtime for routine maintenance.*

[4] Calculated relative to portland cement output; utilization would be higher if calculated to include output of masonry cement.

[5] Includes imported cement. Includes stocks at mills, terminals, and in transit.

[6] Data contain estimates for nonrespondent or incompletely reporting facilities and have been rounded to no more than three significant digits.

[7] Production and capacity data exclude a plant that produced only masonry cement.

[8] Data for Northern California for 2009 are included with those for Southern California.

[9] Data include only those importers or terminals for which district assignations were not possible.

[10] Data may not add to totals shown because of independent rounding.

TABLE 4

MASONRY CEMENT PRODUCTION AND STOCKS IN THE UNITED STATES, BY DISTRICT[1]

(Thousand metric tons unless otherwise specified)

	2008			2009		
District[2]	Number of active plants	Production[3]	Yearend stocks[4]	Number of active plants	Production[3]	Yearend stocks[4]
Maine and New York	4	69	17	4	41	12
Pennsylvania	9	254	56	9	176	46
Indiana and Ohio	6	332	73	6	244	52
Michigan	4	99	34	4	80	28
Iowa, Nebraska, South Dakota	2	W	W	2	W	W
Kansas	2	W	W	2	W	W
Missouri	1	W	W	1	W	W
Florida	5	310	65	6	123	38
Georgia, Maryland, Virginia, West Virginia	6	367	53	6	250	42
South Carolina	3	323	31	3	174	16
Alabama	4	303	63	4	208	61
Kentucky, Mississippi, Tennessee	3	W	W	3	W	W
Arkansas and Oklahoma	4	125	18	3	97	21
Texas	7	274	20	8	202	22
Arizona and New Mexico	3	W	W	3	W	W
Colorado and Wyoming	2	W	W	2	W	W
Idaho, Montana, Nevada, Utah	1	W	W	--	W	W
California, northern	3	59	19	W [5]	W [5]	W [5]
California, southern	5	278	23	7	236	45 [6]
Importers[7]	--	--	3 [6]	--	--	3 [6]
Total[8]	74	3,027	549 [6]	73	1,968	456 [6]

W Withheld to avoid disclosing company proprietary data; included in "Total." -- Zero.

[1] Includes masonry, portland-lime, plastic, and stucco cements. Even where presented unrounded, data are thought to be accurate to no more than three significant digits.

[2] District assignation is the location of the reporting facilities. Specific districts include importers for which district assignations were possible.

[3] Includes cement produced from imported clinker.

[4] Includes imported cement.

[5] Data for 2009 for Northern California is included with those for Southern California.

[6] Data contain estimates for nonrespondent or incompletely reporting facilities.

[7] Data include only those importers or terminals for which district assignations were not possible.

[8] Data may not add totals shown because of independent rounding.

TABLE 5
CLINKER CAPACITY AND PRODUCTION IN THE UNITED STATES IN 2009, BY DISTRICT[1]

District	Number of active plants[2]				Number of kilns[4]	Daily capacity[4, 5] (thousand metric tons)	Average days of routine maintenance[6]	Apparent annual capacity[4, 7] (thousand metric tons)	Production (thousand metric tons)	Percentage of capacity utilized	Yearend stocks (thousand metric tons)
	Process used										
	Wet	Dry	Both[3]	Total							
Maine and New York	2	2	--	4	5	11.3	26.8	3,817	1,856	48.6	100
Pennsylvania	3	5	1	9	18	22.8	13.9 [8]	8,000 [8]	3,523	44.2	271
Illinois	--	3	--	3	6	7.7	7.5	2,728	1,311	48.1	134 [8]
Indiana	1	3 [9]	--	4	8	10.2	25.8	3,430	2,578	75.2	198
Michigan	1	2	--	3	8	14.1	18.6	4,796	2,587	53.9	132
Ohio	1	1	--	2	3	3.3	25.8	1,159	467	40.3	23
Iowa, Nebraska, South Dakota	--	4	1	5	9	14.1	17.9 [8]	4,850 [8]	2,614	53.9	230
Kansas	1	2	--	3	5	8.2	18.5	2,746	1,682	61.3	63
Missouri	1	5	--	6	8	36.3	25.6 [8]	12,400 [8]	4,123	33.3	434
Florida	--	7	--	7	8	23.8	18.1 [8]	8,350 [8]	2,984	35.7	338
Georgia, Maryland, Virginia, West Virginia	--	4	1	5	8	22.1	19.3 [8]	7,570 [8]	3,611	47.7	261
South Carolina	--	3	--	3	3	12.3	26.6	4,185	1,770	42.3	325
Alabama	--	5	--	5	5	16.9	31.0	5,670 [8]	3,240	57.1	196
Kentucky, Mississippi, Tennessee	1	3	--	4	4	10.5	17.5	3,635	1,773	48.8	47
Arkansas and Oklahoma	2	2	--	4	10	8.1	20.5	2,796	1,775	63.5	66
Texas, northern	2	4 [10]	-- [10]	6	12	19.0	18.6	6,586	3,480	52.8	649
Texas, southern	--	5	--	5	6	16.2	15.7	5,648	4,128	73.1	366
Arizona and New Mexico	--	3	--	3	7	8.6	11.6	3,022	1,125	37.2	136
Colorado and Wyoming	--	4	--	4	5	11.5	26.8	3,907	1,992	51.0	228
Idaho, Montana, Nevada, Utah	3	3	--	6	8	8.5	20.3	2,876	1,671	58.1	154 [8]
California	--	9	--	9	11	40.4	26.0	13,667	6,612	48.4	717
Oregon and Washington	1	2	--	3	3	6.0	34.4	2,019	1,213	60.1	64
Total[11]	19	81	3	103	160	332.1	20.1 [8]	114,000 [8]	56,116	49.3	5,130 [8]
Puerto Rico	--	2	--	2	2	5.3	42.5	1,731	802	46.3	75
Grand total[11]	19	83	3	105	162	337.4	20.4 [8]	116,000 [8]	56,918	49.3	5,210 [8]

See footnotes at end of table.

TABLE 5—Continued

CLINKER CAPACITY AND PRODUCTION IN THE UNITED STATES IN 2009, BY DISTRICT[1]

– Zero.

[1] Even where presented unrounded, data are thought to be accurate to no more than three significant digits.

[2] Includes white cement plants. Includes all plants that produced clinker for at least one day during the year.

[3] Plants that can operate both wet and dry kilns, whether or not both types were active during the year.

[4] Includes kilns active for at least one day during the year. For kilns idle all year, excludes those that cannot be restarted, fully permitted, in less than 6 months.

[5] Sum of reported kiln capacities for each plant in a district.

[6] Total days of routine maintenance (summed for all kilns) divided by the number of kilns.

[7] Sum of apparent annual capacities for each kiln. For each kiln, the statistic is calculated as 366 days (leap year) minus days reported for routine maintenance and then multiplied by the unrounded daily capacity.

[8] Data contain estimates for nonrespondents and incompletely reporting facilities and have been rounded to no more than three significant digits.

[9] Includes one semiwet kiln.

[10] Includes as a dry operation one plant, formerly operating both wet and dry kilns, whose wet kilns were idle all year (2009) and which, in 2010, were declared permanently closed.

[11] Data may not add to totals shown because of independent rounding.

TABLE 6
RAW MATERIALS USED TO PRODUCE CLINKER AND CEMENT IN THE UNITED STATES[1, 2]

(Thousand metric tons)

Materials	2008 Clinker	2008 Cement[3]	2009 Clinker	2009 Cement[3]
Calcareous:				
Limestone (aragonite, chalk, coral, marble)	101,000	1,920	73,600	1,510
Cement rock (includes marl)	10,900	50	6,560	--
Cement kiln dust (CKD)[4]	425	304	288	156
Lime[4]	248	15	17	5
Other	41	--	62	--
Aluminous:				
Clay	3,780	--	2,500	3
Shale and schist	3,290	20	2,540	--
Other[5]	849	--	438	--
Ferrous:				
Iron ore	609	--	481	--
Mill scale	702	--	536	--
Other[6]	65	--	40	--
Siliceous:				
Sand, calcium silicates	3,970	--	2,550	--
Sandstone, quartzite, soils, nonpozzolanic rocks	693	--	464	--
Fly ash	2,710 r	95 r	2,290	74
Other ash, including bottom ash	948	--	706	--
Granulated blast furnace slag[7]	81	328	44	192
Other blast furnace slag	262	--	99	--
Steel slag	428	--	169	--
Other slag	67	30	38	--
Natural rock pozzolans[8]	--	9	--	11
Other pozzolans[9]	79	3	45	3
Other:				
Gypsum and anhydrite	--	4,620 r	--	3,367
Other[10]	115	90	79	57
Total[11]	131,000	7,480 r	93,600	5,380
Clinker, imported, raw materials equivalent[12]	--	1,810	--	1,250
Grand total[11]	131,000	9,290 r	93,600	6,630

r Revised. -- Zero.

[1] Excludes Puerto Rico.

[2] Data have been rounded to three significant digits to reflect inherent reporting accuracy and the incorporation of estimates for some facilities.

[3] Includes portland, blended, and masonry cements.

[4] Data are probably underreported.

[5] Includes alumina, aluminum dross, bauxite, spent catalysts, and other aluminous materials.

[6] Includes iron sludges, pyrite, and other ferrous materials.

[7] Includes both ground (GGBFS) and unground material.

[8] Includes pozzolana and burned clays or shales (except where directly reported as clay or shale).

[9] Includes diatomite, silica fume, other microcrystalline silica, and other pozzolans, even if not used as such.

[10] Includes fluorspar and all other materials not listed earlier.

[11] Data may not add to totals shown because of independent rounding.

[12] Converted as the weight of foreign clinker consumed times 1.7.

TABLE 7

CLINKER PRODUCED AND FUEL CONSUMED BY THE U.S. CEMENT INDUSTRY, BY KILN PROCESS[1]

	Clinker production[2]			Conventional fuels[3]				Waste fuels[3]		
Kiln process	Number of plants	Quantity (thousand metric tons)	Percentage of total	Coal[4] (thousand metric tons)	Petcoke (thousand metric tons)	Oil[5] (thousand liters)	Natural gas[6] (thousand cubic meters)	Tires (thousand metric tons)	Solid (thousand metric tons)	Liquid (thousand liters)
2008:										
Wet	22	9,930	12.7	1,230	518	24,300	23,200	91	10	370,000
Dry	81	64,664	82.5	6,440	1,610	28,000	218,000	341	335	354,000
Both[7]	3	3,788	4.8	561	--	--	38,900	6	9	67,200
Total[8]	106	78,382	100.0	8,240	2,130	52,300	280,000	438	354	791,000
2009:										
Wet	19	4,866	8.7	569	157	7,310	96,200	50	16	256,000
Dry[9]	81	50,112	89.3	4,690	1,300	26,500	247,000	263	307	493,000
Both[7]	3	1,138	2.0	186	33	1,810	1,190	--	--	34,600
Total[8]	103	56,116	100.0	5,450	1,490	35,600	344,000	313	324	784,000

-- Zero.

[1] Excludes Puerto Rico.

[2] Clinker production data are all reported. Although unrounded, data are thought to be accurate to no more than three significant digits.

[3] All fuel data have been rounded to no more than three significant digits.

[4] Essentially all reported to be bituminous.

[5] Distilliate and residual fuel oils. Excludes used oils that were reported under liquid wastes.

[6] Includes landfill gas and propane.

[7] Plants that can operate both wet and dry kilns, whether or not both types were active during the year. Includes plants that converted from wet to dry technology during the year. For 2009, excludes one plant as noted in footnote 9.

[8] Data may not add to totals shown because of independent rounding.

[9] Includes one plant that operated a dry kiln in 2009 that had wet kilns which, although technically idle all year, were deemed as closed.

TABLE 8
ELECTRICITY CONSUMED BY U.S. CEMENT PLANTS, BY KILN PROCESS[1]

Plant process	Electricity consumed[2] Generated Number of plants	 Generated Quantity (million kilowatthours)	 Purchased Number of plants	 Purchased Quantity (million kilowatthours)	 Total[3] Number of plants	 Total[3] Quantity (million kilowatthours)	 Total[3] Percentage of total	Cement produced[4] (thousand metric tons)	Average consumption (kilowatthours per ton of cement produced)
2008:									
Integrated plants:									
Wet	--	--	22	1,530	22	1,530	12.4	10,598	145
Dry	3	236	83 [5]	9,960	83 [5]	10,200	82.9	70,279	145
Both[6]	--	--	3	563	3	563	4.6	3,736	151
Total or average[3]	3	236	108 [5]	12,100	108 [5]	12,300	100.0	84,612	145
Grinding plants[7]	--	--	5	130	5	130	--	1,481	88
Exclusions[8]	--	--	3	XX	3	XX	--	216	XX
2009:									
Integrated plants:									
Wet	--	--	19	815	19	815	8.8	5,804	140
Dry[9]	2	223	83 [5]	8,000	83 [5]	8,210	88.6	55,739	148
Both[6]	--	--	3	222	3	222	2.4	1,334	166
Total or average[3]	2	223	105 [5]	9,030	105 [5]	9,260	100.0	62,877	147
Grinding plants[7]	--	--	5	91	6	91	--	908	99
Exclusions[8]	--	--	3	XX	3	XX	--	143	XX

XX Not applicable. -- Zero.

[1] Excludes Puerto Rico.

[2] Electricity data are rounded to no more than three significant digits because they contain estimates.

[3] Data may not add to totals shown because of independent rounding.

[4] Portland and masonry cement. Data are all reported and are unrounded.

[5] Includes two grinding plants whose data were included with the integrated plants.

[6] Plants that can operate both wet and dry kilns, whether or not both types were active during the year. Includes plants that converted from wet to dry technology during the year. For 2009, excludes one plant as noted in footnote 9.

[7] Plants that did not produce clinker but ground clinker from outside sources. Excludes plants that only made masonry cement or just reground one type of portland cement into another, or which also reported a significant component of grinding of excess granulated blast furnace slag.

[8] Plants whose production of portland cement was by simply regrinding of one type into another, or which reported production only of masonry cement.

[9] Includes one plant that operated a dry kiln in 2009 that had wet kilns which, although technically idle all year, were deemed as closed.

TABLE 9
CEMENT SHIPMENTS TO FINAL CUSTOMER, BY DESTINATION AND ORIGIN[1, 2]

(Thousand metric tons)

Destination and origin	Portland cement		Masonry cement	
	2008	2009	2008	2009
Destination:				
Alabama	1,559	1,140	122	85
Alaska[3]	148	146	--	--
Arizona	2,778	1,727	44	26
Arkansas	902	732	49	40
California, northern	3,179	2,133	73	45
California, southern	6,189	4,395	238	170
Colorado	2,156	1,403	14	7
Connecticut[3]	640	478	12	11
Delaware[3]	217	159	7	5
District of Columbia[3]	168	129	(4)	(4)
Florida	5,875	3,946	351	231
Georgia	3,112	1,887	235	131
Hawaii[3]	397	306	4	2
Idaho	507	367	1	(4)
Illinois, excluding Chicago	1,656	1,397	13	10
Illinois, metropolitan Chicago[3]	1,636	1,181	31	19
Indiana	1,719	1,454	56	39
Iowa	1,658	1,448	2	1
Kansas	1,430	1,133	10	7
Kentucky	1,085	870	68	49
Louisiana[3]	2,477	2,135	62	49
Maine	239	185	3	2
Maryland	1,223	902	59	42
Massachusetts[3]	919	702	15	11
Michigan	1,858	1,384	59	42
Minnesota[3]	1,374	1,135	13	12
Mississippi	1,063	805	59	40
Missouri	2,079	1,728	26	19
Montana	349	256	1	1
Nebraska	1,134	1,018	3	2
Nevada	1,651	1,008	15	12
New Hampshire[3]	269	198	4	7
New Jersey[3]	1,594	1,152	59	43
New Mexico	709	534	9	7
New York, eastern	573	476	13	10
New York, western[3]	748	652	23	16
New York, metropolitan[3]	1,637	1,304	73	59
North Carolina[3]	2,343	1,612	229	135
North Dakota[3]	391	375	1	1
Ohio	2,817	2,232	99	78
Oklahoma	1,570	1,338	54	39
Oregon	923	663	1	(4)
Pennsylvania, eastern	1,722	1,270	48	37
Pennsylvania, western	1,082	913	42	33
Rhode Island[3]	139	106	2	1
South Carolina	1,242	822	103	70
South Dakota	453	450	1	1
Tennessee	1,692	1,223	164	108
Texas, northern	6,580	4,255	123	79
Texas, southern	7,668	5,344	198	157
Utah	1,313	1,058	(4)	(4)

See footnotes at end of table.

TABLE 9—Continued
CEMENT SHIPMENTS TO FINAL CUSTOMER, BY DESTINATION AND ORIGIN[1,2]

(Thousand metric tons)

Destination and origin	Portland cement 2008	Portland cement 2009	Masonry cement 2008	Masonry cement 2009
Destination—Continued:				
Vermont[3]	116	95	3	2
Virginia	2,019	1,526	118	80
Washington	2,044	1,437	1	1
West Virginia	504	402	21	14
Wisconsin[3]	1,729	1,410	13	10
Wyoming	497	348	(4)	(4)
Total[5]	93,751	68,885	3,047	2,102
Foreign countries[6]	564	502	(4)	(4)
Puerto Rico	1,397	979	--	(4)
Grand total[5]	95,710	70,366	3,047	2,102
Origin:				
United States	83,178	63,486	2,995	2,070
Foreign countries[7]	11,197	5,948	52	32
Puerto Rico	1,335	932	--	--
Total shipments[5]	95,710	70,366	3,047	2,102

-- Zero.

[1] Includes cement produced from imported clinker and imported cement shipped by domestic producers and importers.

[2] Data are developed from consolidated monthly surveys of shipments by companies and may differ from data in tables 1, 10–12, and 14–15, which are from annual surveys of individual plants and importers. Although presented unrounded, data are thought to be accurate to no more than three significant digits.

[3] Has no cement plants.

[4] Less than ½ unit.

[5] Data may not add to totals shown because of independent rounding.

[6] Includes shipments to U.S. possessions and territories.

[7] Imported cement sold to final customers in the United States as reported by domestic producers and other importers. Data do not match the imports in tables 17–20.

TABLE 10
SHIPMENTS OF PORTLAND CEMENT IN THE UNITED STATES, BY TYPE OF CARRIER[1,2]

(Thousand metric tons)

	Plant to terminal		Plant to customer		Terminal to customer		Total to
	In bulk	In bags[3]	In bulk	In bags[3]	In bulk	In bags[3]	customers[4]
2008:							
Railroad	10,700	108	1,870	3	438	2	2,310
Truck	5,350	308	49,000	1,310	39,900	644	90,900
Barge and boat	7,230	3	323	43	37	--	403
Total[4]	23,300	419	51,200	1,360	40,400	647	93,600 [5]
2009:							
Railroad	9,580	8	1,460	2	528	4	2,000
Truck	4,000	116	36,000	1,040	29,400	400	66,900
Barge and boat	7,120	--	55	--	--	--	55
Total[4]	20,700	125	37,500	1,040	30,000	404	69,000 [5]

-- Zero.

[1] Includes imported cement and cement made from imported clinker. Excludes Puerto Rico.

[2] Data are rounded to no more than three significant digits because they contain estimates.

[3] Includes packages, bags, and supersacks.

[4] Data may not add to totals shown because of independent rounding.

[5] Shipments are based on an annual survey of plants and importers; may differ from totals in table 9, which are based on consolidated monthly data.

TABLE 11

PORTLAND CEMENT SHIPPED IN THE UNITED STATES, BY DISTRICT[1]

District[4]	2008 Quantity[3] (thousand metric tons)	2008 Value[2] Total (thousands)	2008 Value[2] Average (per metric ton)	2009 Quantity[3] (thousand metric tons)	2009 Value[2] Total (thousands)	2009 Value[2] Average (per metric ton)
Maine and New York	3,820 [5]	$403,000 [5]	$105.50 [5]	2,580 [5]	$250,000 [5]	$97.00 [5]
Pennsylvania, eastern	3,838	382,000 [5]	99.50 [5]	2,995	285,000 [5]	95.00 [5]
Pennsylvania, western	1,248	121,000 [5]	97.00 [5]	949	90,800 [5]	95.50 [5]
Illinois	2,810	279,000 [5]	99.00 [5]	2,014	191,586	95.11
Indiana	2,346	205,153	87.46	1,951	169,069	86.66
Michigan	4,986	508,000 [5]	102.00 [5]	4,114	406,143	98.72
Ohio	733	71,200	97.20	582	55,691	95.69
Iowa, Nebraska, South Dakota	4,366	453,124	103.79	3,382	365,298	108.01
Kansas	2,115	217,519	102.85	1,627	166,000 [5]	102.00 [5]
Missouri	5,058	490,008	96.89	4,219	414,000 [5]	98.00 [5]
Florida	5,763	599,000 [5]	104.00 [5]	3,790 [5]	371,000 [5]	98.00 [5]
Georgia, Virginia, West Virginia	2,299	243,026	105.71	4,141 [6]	367,335 [6]	88.70 [6]
Maryland	2,957	240,275	81.25	W [6]	W [6]	W [6]
South Carolina	2,756	267,411	97.02	1,826	165,160	90.46
Alabama	4,444	432,000 [5]	97.00 [5]	3,515	315,408	89.72
Kentucky, Mississippi, Tennessee	2,673	268,412	100.43	1,885	187,660	99.53
Arkansas and Oklahoma	2,643	262,806	99.44	2,300	231,363	100.60
Texas, northern	7,316	733,000 [5]	100.00 [5]	4,557	453,000 [5]	99.50 [5]
Texas, southern	6,417	645,641	100.61	4,730	452,380	95.65
Arizona and New Mexico	3,106	391,316	125.97	2,173	255,708	117.68
Colorado and Wyoming	2,554	273,303	107.02	1,932	190,508	98.63
Idaho, Montana, Nevada, Utah	2,589	260,250	100.53	2,063	199,834	96.87
Alaska and Hawaii	497	86,882	174.79	406	66,690	164.27
California, northern	2,481	256,000 [5]	103.00 [5]	W [7]	W [7]	W [7]
California, southern	7,540	784,938	104.10	6,835 [7]	618,000 [5, 7]	90.50 [5, 7]
Oregon and Washington	2,196	212,013	96.53	1,651	150,011	90.85
Importers[8]	4,060 [5]	478,000 [5]	117.50 [5]	2,747	315,000 [5]	115.00 [5]
Total or average[9]	93,600 [5, 10]	9,560,000 [5]	102.00 [5]	69,000 [5, 10]	6,730,000 [5]	97.50 [5]
Puerto Rico	1,381	W	W	978 [5]	W	W
Grand total[9]	95,000 [5, 10]	W	W	69,900 [5, 10]	W	W

W Withheld to avoid disclosing company proprietary data.

[1] Includes gray and white portland cement. Includes cement made from imported clinker. Even where presented unrounded, data are thought to be accurate to no more than three significant digits.

[2] Values are mill net or ex-plant (free on board) valuations of total sales to final customers, including sales from plants' external distribution terminals. The data are ex-terminal for independently reporting terminals. Data include all varieties of portland cement and both bulk and bag shipments. Unless otherwise specified, data are presented unrounded. Unrounded or not, unit value data should be viewed as value indicators, good to no better than the nearest $0.50 or $1.00 per metric ton.

[3] Tonnages are those by reporting entities in the district but may include shipments into other districts. They differ from the data in table 9, which are the actual reported sales into the specific States.

[4] District is the location of the reporting entities, not necessarily the location of sales (see table 9 for sales data, by State). Specific districts include shipments by importers where district assignations were possible.

[5] Data are rounded (unit values to the nearest $0.50) because they include estimates.

[6] For 2009, data for Maryland are included with Georgia, Virginia, West Virginia district.

[7] For 2009, data for Northern California are included with those for Southern California.

[8] Importers for which district assignations were not possible.

[9] Data may not add to totals shown because of independent rounding.

[10] Shipments are based on an annual survey of plants and importers; may differ from totals in table 9, which are based on consolidated monthly data.

TABLE 12

MASONRY CEMENT SHIPPED IN THE UNITED STATES, BY DISTRICT[1, 2]

	2008			2009		
		Value[3]			Value[3]	
District[5]	Quantity[4] (thousand metric tons)	Total (thousands)	Average (per metric ton)	Quantity[4] (thousand metric tons)	Total (thousands)	Average (per metric ton)
Maine and New York	82	$10,100[6]	$124.50[6]	56	$6,265	$112.54
Pennsylvania	241	32,300[6]	134.00[6]	187	25,300[6]	135.00[6]
Illinois, Indiana, Ohio	335	47,725	142.55	230	33,900[6]	147.50[6]
Michigan	136	16,400[6]	121.00[6]	95	11,538	121.87
Iowa, Nebraska, South Dakota	19	2,161	114.53	15	1,921	128.09
Kansas and Missouri	84	13,427	159.64	51	6,353	124.50
Florida	282	42,800[6]	151.50[6]	192[6]	29,100[6]	151.50[6]
Georgia, Maryland, Virginia, West Virginia	320	57,900[6]	180.50[6]	214	36,547	170.78
South Carolina	305	39,409	129.07	169	21,376	126.43
Alabama	353	44,247	125.38	242	29,735	122.90
Kentucky, Mississippi, Tennessee	80	11,784	146.57	57	8,360	146.39
Arkansas and Oklahoma	125	15,070	120.65	93	11,100[6]	119.00[6]
Texas, northern	155	26,100[6]	168.00[6]	W[7]	W[7]	W[7]
Texas, southern	146	18,300[6]	125.50[6]	221[7]	31,000[7]	140.40[7]
Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming	67	9,259	137.47	42	5,387	129.76
Alaska and Hawaii	3	946	279.55	2	620	289.54
California, northern; Oregon; Washington	51	6,511	128.31	W[8]	W[8]	W[8]
California, southern	279	36,213	129.87	232[6, 8]	27,700[6, 8]	119.50[6, 8]
Importers[9]	10[6]	1,950[6]	196.00[6]	6[6]	1,220[6]	191.50[6]
Total or average[10]	3,070[6, 11]	433,000[6]	140.50[6]	2,100[6, 11]	287,000[6]	136.50[6]

W Witheld to avoid disclosing company proprietary data; included in "Total."

[1] Shipments are those by cement companies to final customers and include imported cement and cement made from imported clinker. Sales are those by cement plants and exclude masonry cement made by portland cement customers from purchased portland cement and which was then resold and (or) consumed. Data exclude Puerto Rico, which did not record any masonry cement sales. Even where presented unrounded, data are thought to be accurate to no more than three significant digits.

[2] Data include true masonry, plastic, portland-lime, and stucco cements.

[3] Values are mill net or ex-plant (free on board) valuations of total sales to final customers, including sales from plants external distribution terminals. The data are ex-terminal for independently reporting terminals. Data include both bulk and bag shipments. Unless otherwise specified, data are presented unrounded. Unrounded or not, unit value data should be viewed as value indicators, good to no better than the nearest $0.50 or even $1.00 per metric ton.

[4] Tonnages are those by reporting entities in the district but may include shipments into other districts. They differ from the data in table 9, which are the actual reported sales into the specific States.

[5] District is the location of the reporting entities, not necessarily the location of sales (see table 9 for sales data, by State). Specific districts include importers for which district assignations were possible.

[6] Data are rounded (unit values to the nearest $0.50) because they include estimates.

[7] For 2009, data for Northern Texas are included with those for Southern Texas.

[8] For 2009, data for Northern California, Oregon, and Washington are included with those for Southern California.

[9] Importers for which district assignations were not possible.

[10] Data may not add to totals shown because of independent rounding.

[11] Shipments are based on an annual survey of plants and importers; may differ from totals in table 9, which are based on consolidated monthly data.

TABLE 13
AVERAGE MILL NET VALUE OF CEMENT SOLD IN THE UNITED STATES[1, 2]

(Dollars per metric ton)

Year	Portland cement			Masonry cement	All cement
	Gray	White[3]	Total		
2008	101.00	221.50	102.00	141.00	103.50
2009	96.50	211.00	97.50	136.50	99.00

[1] Values are average of sales to final customers, free on board the plant or independently reporting terminal. Values include any bagging charges, but exclude delivery charges to customers or to exterminal terminals. Data exclude Puerto Rico.

[2] Data are rounded to the nearest $0.50 per metric ton because they contain estimates.

[3] Data for white cement include a component of resales showing significant price markups.

TABLE 14
PORTLAND CEMENT SHIPMENTS IN 2009, BY DISTRICT AND TYPE OF CUSTOMER[1]

(Thousand metric tons)

District[2]	Ready-mixed concrete	Concrete product manufacturers	Contractors	Building material dealers	Oil well, mining, waste stabilization	Government and other[3]	Total[4, 5]
Maine and New York	1,930	288	77	220	--	60	2,580
Pennsylvania, eastern	1,750	739	182	206	--	115	2,995
Pennsylvania, western	625	159	113	12	7	32	949
Illinois	1,390	182	164	25	164	91	2,014
Indiana	1,480	254	157	42	6	11	1,951
Michigan	3,300	387	309	80	14	29	4,114
Ohio	442	71	58	10	1	--	582
Iowa, Nebraska, South Dakota	2,520	301	418	32	51	62	3,382
Kansas	1,250	173	96	49	38	19	1,627
Missouri	3,080	390	579	56	64	47	4,219
Florida	2,640	783	261	98	--	6	3,790
Georgia, Maryland, Virginia, West Virginia	2,970	702	231	124	5	106	4,141
South Carolina	1,250	297	116	37	3	123	1,826
Alabama	2,460	458	370	111	15	99	3,515
Kentucky, Mississippi, Tennessee	1,480	220	90	61	23	14	1,885
Arkansas and Oklahoma	1,490	90	530	103	75	16	2,300
Texas, northern	2,870	367	662	114	456	84	4,557
Texas, southern	3,150	441	598	220	315	6	4,730
Arizona and New Mexico	1,680	310	125	38	18	2	2,173
Colorado and Wyoming	1,410	132	170	52	142	28	1,932
Idaho, Montana, Nevada, Utah	1,440	157	137	70	217	43	2,063
Alaska and Hawaii	317	61	9	18	--	--	406
California	4,930	1,150	346	306	89	20	6,835
Oregon and Washington	1,280	186	83	73	24	4	1,651
Importers[6]	2,020	272	258	54	49	99	2,747
Total[5]	49,100	8,570	6,140	2,210	1,780	1,120	69,000
Puerto Rico	504	91	5	377	--	--	978
Grand total[5]	49,700	8,660 [7]	6,150 [8]	2,590	1,780 [9]	1,120	69,900

-- Zero.

[1] Includes imported cement and cement made from imported clinker. Except for district totals, data have been rounded to three significant digits, but are likely accurate to only two significant digits. District totals are likely accurate to no more than three significant digits.

[2] District is the location of the reporting entity, not the location of sales (see table 9 for sales data, by State). Specific districts include shipments by importers for which district assignations were possible.

[3] Includes shipments to miscellaneous customer types and for which customer types were not specified.

[4] District totals are unrounded except in accord with table 11.

[5] Data may not add to totals shown because of independent rounding.

[6] Shipments by importers for which district assignations were not possible.

[7] Grand total shipments to concrete product manufacturers include brick and block—3,090; precast and prestressed—2,330; pipe—929; and other or unspecified—2,300.

[8] Grand total shipments to contractors include airport—156; road paving—2,910; soil cement—1,575; and other or unspecified—1,500.

[9] Grand total shipments include oil well drilling—1,380; mining—228; and waste stabilization—173.

TABLE 15
PORTLAND CEMENT SHIPMENTS IN THE UNITED STATES, BY TYPE OF CEMENT[1, 2, 3]

(Thousand metric tons)

Type[4]	2008	2009
General use and moderate heat (Types I and II)[5, 6]	73,600	55,000
High early strength (Type III)	3,450	2,460
Sulfate resisting (Type V)[5]	11,800	8,610
Block	509	167
Oil well	1,470	846
White[7]	823	577
Blended:[8]		
Portland, natural pozzolans	38	34
Portland, ground granulated blast furnace slag	981	580
Portland, fly ash	381	357
Portland, other pozzolans[9]	563	325
Total blended[10]	1,960	1,300
Expansive and regulated fast setting	36	13
Miscellaneous[11]	(12)	27
Grand total[10]	93,600	69,000

[1] Includes sales of imported cement. Excludes Puerto Rico.

[2] Data are rounded to no more than three significant digits.

[3] Gray portland-type cements unless otherwise specified.

[4] Sold mostly under specifications ASTM C-150, ASTM C-595, and ASTM C-1157.

[5] Type II/V and similar sulfate-resisting cement hybrids are included within Type V.

[6] Includes ASTM C-1157 general use cements that contain no pozzolans.

[7] White or colored portland-type cements. Most are Types I or II but may include Types III and V and block cements.

[8] Cements sold under ASTM C-590 and those under ASTM C-1157 that contain pozzolans.

[9] Includes blends with cement kiln dust, silica fume, or other pozzolans, and blends containing multiple pozzolans.

[10] Data may not add to totals shown because of independent rounding.

[11] Includes low heat (Type IV), waterproof, and other portland-type cements.

[12] Less than ½ unit.

TABLE 16

U.S. EXPORTS OF HYDRAULIC CEMENT AND CLINKER, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

Country	2008		2009	
	Quantity	Value[2]	Quantity	Value[2]
United States:				
Angola	1	183	2	323
Anguilla	1	42	4	255
Aruba	1	352	2	336
Bahamas	28	3,853	48	5,628
Barbados	1	153	(3)	61
Belize	1	224	36	1,513
Bermuda	16	1,430	(3)	224
Brazil	1	136	(3)	39
Canada	711	82,814	674	79,836
Cayman Islands	3	293	(3)	95
China	1	354	(3)	133
Colombia	1	675	1	680
Costa Rica	1	89	(3)	19
Dominica	--	--	1	12
Dominican Republic	3	322	2	219
Greece	7	352	15	729
Haiti	10	726	1	62
Hong Kong	(3)	98	1	326
Ireland	(3)	101	4	225
Jamaica	(3)	25	26	2,737
Japan	(3)	26	1	225
Mexico	23	4,540	23	5,915
Netherlands Antilles	1	187	1	196
Nicaragua	1	414	(3)	3
Niger	2	114	--	--
Pakistan	(3)	3	1	43
Panama	3	413	28	3,794
Peru	1	255	1	198
Russia	(3)	8	1	47
Saudi Arabia	1	259	1	844
St. Christopher and Nevis	(3)	133	2	102
Sweden	1	90	1	77
Taiwan	1	366	(3)	149
Turks and Caicos Islands	1	267	(3)	55
Other	5 r	3,169 r	5	2,230
Total[4]	823	102,466	884	107,330
Puerto Rico:				
Anguilla	12	846	--	--
British Virgin Islands	13	1,778	15	1,807
Netherlands Antilles	1	332	(3)	5
Turks and Caicos Islands	8	545	1	152
Other	1 r	131 r	(3)	30
Total[4]	34	3,631	16	1,994
Grand total[4]	858	106,097	900	109,323

r Revised. -- Zero.

[1] Includes portland and masonry cements.

[2] Free alongside ship value. The value of exports at the U.S. seaport or border point of export is based on the transaction price, including inland freight, insurance, and other charges incurred in placing the merchandise alongside the carrier. The value excludes the cost of loading.

[3] Less than ½ unit.

[4] Data may not add to totals shown because of independent rounding.

Source: U.S. Census Bureau.

TABLE 17
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

Country	2008			2009		
		Value			Value	
	Quantity	Customs[2]	C.i.f.[3]	Quantity	Customs[2]	C.i.f.[3]
United States:						
Algeria	4	316	520	14	1,576	2,123
Brazil	36	2,780	3,225	--	--	--
Canada	4,104	338,225	356,325	3,426	272,829	291,298
China	2,020	103,055	164,401	608	35,251	50,161
Colombia	964	67,117	90,608	654	39,799	56,216
Croatia	34	10,048	13,061	15	5,687	6,890
Denmark	99	9,768	14,898	69	9,924	12,302
Dominican Republic	11	786	1,082	4	307	381
Egypt	57	4,873	7,331	55	6,345	7,965
France	108	22,266	24,999	65	20,373	21,607
Germany	1	464	564	(4)	265	340
Greece	213	11,717	18,514	186	10,705	12,429
India	1	98	153	1	151	209
Japan	6	773	1,038	1	523	654
Korea, Republic of	1,229	50,550	85,899	855	34,694	56,700
Mexico	1,071	84,714	99,673	366	35,342	39,132
Netherlands	4	3,894	4,800	2	1,925	2,539
Norway	20	897	897	--	--	--
Peru	92	4,727	7,509	--	--	--
Sweden	261	13,192	24,583	74	3,821	7,074
Taiwan	855	36,424	55,867	254	11,332	16,677
Thailand	77	5,165	7,909	21	2,594	3,801
Turkey	96	5,257	12,201	95	7,858	12,220
United Kingdom	4	1,712	2,076	1	153	281
Other	(4) r	69 r	74 r	(4)	138	148
Total[5]	11,365	778,888	998,208	6,767	501,592	601,148
Puerto Rico:						
China	78	3,270	5,701	(4)	5	7
Colombia	4	529	665	5	674	862
Korea, Republic of	54	3,861	5,812	27	1,350	2,322
Mexico	17	1,981	2,808	14	1,641	2,216
Spain	(4)	25	33	81	5,694	7,064
Other	(4)	14 r	18 r	(4)	169	174
Total[5]	153	9,681	15,037	127	9,532	12,645
Grand total[5]	11,519	788,569	1,013,244	6,894	511,125	613,793

rRevised. -- Zero.

[1] Includes portland, masonry, and other hydraulic cements.

[2] Customs value. The price actually paid or payable for merchandise when sold for exportation to the United States, excluding U.S. import duties, freight, insurance, and other charges incurred in bringing the merchandise to the United States.

[3] Cost, insurance, and freight. The import value represents the customs value plus insurance, freight, and other delivery charges to the first port of entry.

[4] Less than ½ unit.

[5] Data may not add to totals shown because of independent rounding.

Source: U.S. Census Bureau.

TABLE 18
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY CUSTOMS DISTRICT AND COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2008			2009		
		Value			Value	
Customs district and country	Quantity	Customs[2]	C.i.f.[3]	Quantity	Customs[2]	C.i.f.[3]
United States:						
Anchorage, AK:						
Canada	7	419	1,479	9	745	2,267
China	1	98	106	15	1,036	1,561
Japan	5	187	282	--	--	--
Korea, Republic of	102	4,471	8,689	72	3,165	5,658
Taiwan	--	--	--	16	1,047	1,066
Total[4]	114	5,175	10,556	112	5,994	10,552
Baltimore, MD:						
Germany	(5)	13	15	--	--	--
Netherlands	(5)	229	259	(5)	42	48
United Kingdom	--	--	--	(5)	20	21
Total[4]	(5)	242	274	(5)	62	70
Boston, MA, Canada	45	2,537	4,584	77	4,196	6,824
Buffalo, NY:						
Canada	707	57,564	60,681	574	48,103	52,028
France	(5)	60	61	--	--	--
Germany	(5)	3	3	--	--	--
Japan	--	--	--	(5)	13	13
Total[4]	708	57,627	60,744	574	48,116	52,041
Charleston, SC:						
China	--	--	--	(5)	5	9
Germany	--	--	--	(5)	12	13
Netherlands	--	--	--	(5)	41	47
Total[4]	--	--	--	(5)	59	70
Chicago, IL:						
Croatia	(5)	38	53	--	--	--
Denmark	(5)	15	16	--	--	--
France	(5)	3	25	--	--	--
Germany	(5)	2	3	--	--	--
Japan	(5)	220	259	(5)	107	117
Netherlands	(5)	231	296	(5)	92	141
Poland	(5)	41	44	(5)	19	22
Total[4]	1	551	696	(5)	218	280
Cleveland, OH:						
Canada	485	40,608	41,506	493	34,399	36,894
China	(5)	13	17	--	--	--
Croatia	1	261	354	--	--	--
Netherlands	(5)	37	57	(5)	137	158
Poland	--	--	--	(5)	21	24
Total[4]	485	40,919	41,935	494	34,558	37,077
Columbia-Snake, OR-WA						
Canada	135	8,012	8,756	55	4,256	4,503
China	653	26,857	44,713	237	13,016	19,757
Thailand	(5)	2	4	--	--	--
Total[4]	788	34,872	53,473	292	17,272	24,259

See footnotes at end of table.

TABLE 18—Continued
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY CUSTOMS DISTRICT AND COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2008			2009		
		Value			Value	
Customs district and country	Quantity	Customs[2]	C.i.f.[3]	Quantity	Customs[2]	C.i.f.[3]
United States—Continued:						
Dallas, Fort Worth, TX:						
Italy	(5)	3	4	--	--	--
Netherlands	--	--	--	(5)	34	95
Total[4]	(5)	3	4	(5)	34	95
Detroit, MI:						
Canada	837	76,193	77,285	841	66,897	68,458
China	--	--	--	(5)	41	42
Germany	(5)	5	5	--	--	--
Netherlands	(5)	260	356	(5)	60	100
Total[4]	838	76,457	77,645	841	66,998	68,600
El Paso, TX, Mexico	384	31,680	35,277	275	23,449	25,875
Great Falls, MT:						
Canada	9	468 r	503	(5)	20	21
China	(5)	24 r	32	(5)	143	171
Germany	(5)	13	21	--	--	--
Japan	--	--	--	(5)	2	2
United Kingdom	--	--	--	(5)	23	33
Total[4]	9	505 r	556	(5)	189	227
Honolulu, HI:						
China	10	705	1,597	(5)	14	47
Korea, Republic of	--	--	--	84	3,569	7,329
Taiwan	373	16,848	25,388	188	8,281	12,233
Thailand	(5)	3	6	3	188	552
Total[4]	383	17,556	26,991	276	12,052	20,160
Houston-Galveston, TX:						
Algeria	1	94	122	6	728	1,022
China	93	4,219	6,940	2	186	274
Colombia	403	30,692	39,484	235	14,822	20,624
Croatia	(5)	11	12	--	--	--
Denmark	--	--	--	(5)	3	3
Egypt	22	1,892	2,774	28	3,230	3,988
France	(5)	69	79	(5)	44	50
Germany	(5)	109	133	(5)	78	93
Korea, Republic of	799	31,413	51,352	472	19,219	30,821
Sweden	108	6,076	8,957	--	--	--
Taiwan	449	16,972	27,229	49	1,968	3,198
Turkey	1	58	89	--	--	--
Total[4]	1,876	91,605	137,171	793	40,278	60,074
Laredo, TX, Mexico	133	15,994	16,939	85	11,467	12,646
Los Angeles, CA:						
Algeria	2	179	328	--	--	--
China	505	23,241	42,027	21	2,408	2,876
Colombia	(5)	28	43	--	--	--

See footnotes at end of table.

TABLE 18—Continued
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY CUSTOMS DISTRICT AND COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2008			2009		
		Value			Value	
Customs district and country	Quantity	Customs[2]	C.i.f.[3]	Quantity	Customs[2]	C.i.f.[3]
United States—Continued:						
Los Angeles, CA—Continued:						
Croatia	(5)	109	180	(5)	220	273
Egypt	11	964	1,667	1	68	72
Germany	(5)	188	206	(5)	53	72
India	--	--	--	(5)	24	25
Japan	(5)	36	51	--	--	--
Lithuania	(5)	13	13	(5)	26	28
Thailand	19	2,285	3,521	12	1,629	2,202
United Kingdom	(5)	12	12	(5)	80	194
Total[4]	538	27,055	48,048	35	4,508	5,741
Miami, FL:						
Algeria	1	43	70	7	848	1,101
China	(5)	23	36	(5)	41	73
Colombia	11	1,464	1,837	6	790	997
Denmark	3	414	529	--	--	--
Egypt	23	1,971	2,811	19	2,197	2,807
Italy	(5)	2	2	--	--	--
Mexico	98	9,869	12,580	5	410	590
Sweden	239	10,596	20,770	73	3,270	6,455
Turkey	--	--	--	74	6,618	9,585
Total[4]	375	24,382	38,636	185	14,174	21,609
Minneapolis, MN:						
Canada	154	17,524	17,541	113	12,105	12,117
China	--	--	--	(5)	15	15
Denmark	(5)	6	6	--	--	--
United Kingdom	(5)	11	11	(5)	15	15
Total[4]	154	17,541	17,558	113	12,136	12,148
Mobile, AL, Mexico	--	--	--	(5)	7	12
New Orleans, LA:						
China	26	5,076	6,461	5	1,062	1,269
Croatia	27	7,929	9,887	15	5,410	6,542
Korea, Republic of	45	1,506	2,412	34	1,273	1,961
Peru	62	3,205	4,652	--	--	--
Taiwan	--	--	--	1	36	180
Turkey	95	5,199	12,112	21	1,240	2,634
Total[4]	256	22,915	35,525	75	9,021	12,586
New York, NY:						
Colombia	16	777	1,650	(5)	68	116
Croatia	(5)	9	11	(5)	57	75
Denmark	38	4,440	6,564	24	2,804	3,655
France	--	--	--	3	107	110
Germany	(5)	14	19	(5)	22	23

See footnotes at end of table.

TABLE 18—Continued
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY CUSTOMS DISTRICT AND COUNTRY[1]

(Thousand metric tons and thousand dollars)

Customs district and country	2008			2009		
		Value			Value	
	Quantity	Customs[2]	C.i.f.[3]	Quantity	Customs[2]	C.i.f.[3]
United States—Continued:						
New York, NY—Continued:						
Greece	213	11,717	18,514	186	10,705	12,429
Netherlands	(5)	336	398	(5)	79	105
Norway	20	897	897	--	--	--
Portugal	--	--	--	(5)	34	35
Sweden	3	1,670	1,856	--	--	--
United Kingdom	(5)	41	72	--	--	--
Total[4]	291	19,902	29,982	214	13,876	16,550
Nogales, AZ, Mexico	348	21,095	25,919	(5)	9	10
Norfolk, VA:						
Canada	113	8,044	8,940	53	5,003	5,373
China	(5)	9	11	--	--	--
Egypt	--	--	--	3	389	482
France	108	22,121	24,818	63	20,222	21,447
Germany	(5)	14	17	--	--	--
Netherlands	(5)	353	464	(5)	34	39
Sweden	(5)	79	89	1	551	619
United Kingdom	4	1,647	1,980	--	--	--
Total[4]	225	32,267	36,319	120	26,198	27,961
Ogdensburg, NY:						
Canada	399	41,749	42,237	248	23,489	23,989
Germany	--	--	--	(5)	3	3
South Africa	--	--	--	(5)	2	2
Total[4]	399	41,749	42,237	248	23,494	23,994
Pembina, ND						
Canada	173	10,174	10,293	162	12,370	12,455
France	(5)	5	5	--	--	--
Total[4]	173	10,179	10,298	162	12,370	12,455
Philadelphia, PA:						
Belgium	(5)	6	7	(5)	5	5
China	(5)	33	33	--	--	--
Germany	(5)	104	143	(5)	92	131
Korea, Republic of	137	5,032	11,590	139	4,988	7,063
Netherlands	1	1,275	1,463	1	814	937
Thailand	48	1,629	2,379	--	--	--
United Kingdom	--	--	--	(5)	14	17
Total[4]	187	8,079	15,616	140	5,913	8,153
Portland, ME, Canada	75	9,765	10,410	37	4,469	4,954
Providence, RI:						
Canada	80	4,572	8,488	62	4,069	6,273

See footnotes at end of table.

TABLE 18—Continued
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY CUSTOMS DISTRICT AND COUNTRY[1]

(Thousand metric tons and thousand dollars)

Customs district and country	2008			2009		
		Value			Value	
	Quantity	Customs[2]	C.i.f.[3]	Quantity	Customs[2]	C.i.f.[3]
United States—Continued:						
Providence, RI—Continued:						
Colombia	48	2,502	3,909	--	--	--
Peru	29	1,522	2,857	--	--	--
Total[4]	158	8,596	15,253	62	4,069	6,273
San Diego, CA, Taiwan	13	515	517	--	--	--
San Francisco, CA:						
China	370	16,786	27,248	211	10,114	13,216
Egypt	1	46	79	1	108	173
France	(5)	9	12	--	--	--
India	1	98	153	1	127	184
Netherlands	(5)	18	37	--	--	--
Taiwan	20	1,036	1,679	--	--	--
Thailand	9	1,150	1,806	6	777	1,047
Total[4]	400	19,143	31,013	219	11,126	14,620
Savannah, GA:						
China	(5)	10	12	--	--	--
Colombia	258	17,005	23,652	221	12,861	18,609
Egypt	--	--	--	3	354	443
Japan	--	--	--	(5)	2	2
Netherlands	1	537	713	(5)	223	364
Portugal	--	--	--	(5)	31	31
Thailand	1	96	194	--	--	--
Total[4]	259	17,649	24,570	224	13,471	19,450
Seattle, WA:						
Canada	757	45,848	48,079	611	42,802	44,572
China	362	25,961	35,167	117	7,158	10,833
Japan	1	331	447	1	398	519
Korea, Republic of	123	6,170	9,308	54	2,480	3,869
Netherlands	(5)	188	257	(5)	40	61
Taiwan	(5)	1,053	1,055	--	--	--
Total[4]	1,243	79,551	94,312	783	52,879	59,853
St. Albans, VT:						
Canada	126	14,748	15,543	89	9,904	10,571
Germany	--	--	--	(5)	4	4
Total[4]	126	14,748	15,543	89	9,907	10,575
St. Louis, MO:						
China	--	--	--	(5)	11	18
Croatia	6	1,690	2,564	--	--	--
Netherlands	(5)	430	500	(5)	329	442
Total[4]	6	2,120	3,064	(5)	340	459

See footnotes at end of table.

TABLE 18—Continued
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY CUSTOMS DISTRICT AND COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2008			2009		
		Value			Value	
Customs district and country	Quantity	Customs[2]	C.i.f.[3]	Quantity	Customs[2]	C.i.f.[3]
United States—Continued:						
Tampa, FL:						
Brazil	36	2,780	3,225	--	--	--
Colombia	39	2,103	2,865	58	3,225	4,557
Denmark	58	4,893	7,782	45	7,117	8,644
Korea, Republic of	24	1,958	2,548	--	--	--
Spain	(5)	4	4	--	--	--
Sweden	19	847	1,868	--	--	--
Total[4]	175	12,584	18,292	103	10,342	13,201
U.S. Virgin Islands:						
Colombia	2	213	219	--	--	--
Dominican Republic	11	786	1,082	4	307	381
Total[4]	13	998	1,300	4	307	381
Wilmington, NC, Colombia	186	12,333	16,952	134	8,033	11,313
U.S. total[4]	11,365	778,888	998,208	6,767	501,592	601,148
Puerto Rico (San Juan):						
China	78	3,270	5,701	(5)	5	7
Colombia	4	529	665	5	674	862
Dominican Republic	--	--	--	(5)	169	174
Korea, Republic of	54	3,861	5,812	27	1,350	2,322
Mexico	17	1,981	2,808	14	1,641	2,216
Peru	(5)	14	18	--	--	--
Spain	(5)	25	33	81	5,694	7,064
Total[4]	153	9,681	15,037	127	9,532	12,645
Grand total[4]	11,519	788,569	1,013,244	6,894	511,125	613,793

[r] Revised. -- Zero.

[1] Includes all varieties of hydraulic cement and clicker.

[2] Customs value. The price actually paid or payable for merchandise when sold for exportation to the United States, excluding U.S. import duties, freight, insurance, and other charges incurred in bringing the merchandise to the United States.

[3] Cost, insurance, and freight. The import value represents the customs value plus insurance, freight, and other delivery charges to the first port of entry.

[4] Data may not add to totals shown because of independent rounding.

[5] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 19
U.S. IMPORTS FOR CONSUMPTION OF GRAY PORTLAND CEMENT, BY COUNTRY

(Thousand metric tons and thousand dollars)

Country	2008			2009		
		Value			Value	
	Quantity	Customs[1]	C.i.f.[2]	Quantity	Customs[1]	C.i.f.[2]
United States:						
Brazil	36	2,780	3,225	--	--	--
Canada	3,294	259,073	275,818	2,642	205,197	222,340
China	1,906	81,907	137,987	573	30,463	44,369
Colombia	891	60,180	81,614	636	37,333	52,800
Dominican	11	786	1,082	4	307	381
France	(3)	27	34	3	107	110
Greece	213	11,717	18,514	186	10,705	12,429
Japan	5	187	282	(3)	5	5
Korea, Republic of	1,227	50,410	85,539	854	34,641	56,563
Mexico	744	45,002	55,076	185	11,770	13,305
Norway	20	897	897	--	--	--
Peru	92	4,727	7,509	--	--	--
Sweden	257	11,443	22,638	73	3,270	6,455
Taiwan	855	35,371	54,813	254	11,332	16,677
Thailand	48	1,629	2,379	3	188	552
United Kingdom	1	65	96	(3)	46	50
Other	(3) r	106 r	126 r	(3)	164	269
Total[4, 5]	9,599	566,307	747,629	5,414	345,529	426,307
Puerto Rico:						
China	78	3,270	5,701	--	--	--
Korea, Republic of	54	3,861	5,812	27	1,350	2,322
Spain	(3)	6	8	81	5,694	7,064
Total[4, 5]	132	7,137	11,521	108	7,044	9,386
Grand total[4, 5]	9,731	573,443	759,150	5,521	352,572	435,693

r Revised. -- Zero.

[1] The price actually paid or payable for merchandise when sold for exportation to the United States, excluding U.S. import duties, freight, insurance, and other charges incurred in bringing the merchandise to the United States.

[2] Cost, insurance, and freight. The import value represents the customs value plus insurance, freight, and other delivery charges to the first port of entry.

[3] Less than ½ unit.

[4] Data may not add to totals shown because of independent rounding.

[5] Total imports do not include gray portland cement that was misregistered by importers under the white cement tariff code and which has been included in table 20.

Source: U.S. Census Bureau.

TABLE 20
U.S. IMPORTS FOR CONSUMPTION OF WHITE CEMENT, BY COUNTRY

(Thousand metric tons and thousand dollars)

Country	2008			2009		
		Value			Value	
	Quantity	Customs[1]	C.i.f.[2, 3]	Quantity	Customs[1]	C.i.f.[2, 3]
United States:						
Algeria	4	316	520	14	1,576	2,123
Canada	296	40,213	41,086	251	33,932	34,681
China	88	15,869	19,697	29	3,396	4,125
Colombia	58	6,491	8,276	18	2,466	3,415
Denmark	99	9,747	14,875	69	9,921	12,300
Egypt	55	4,724	7,087	53	6,028	7,628
India	1	98	153	1	130	178
Korea, Republic of	2	140	360	2	53	137
Mexico	237	29,222	32,871	113	15,822	17,357
Thailand	29	3,536	5,530	18	2,406	3,249
Turkey	96	5,257	12,201	95	7,858	12,220
United Kingdom	--	--	--	1	99	219
Other	(4) r	1,056 r	1,058 r	(4)	7	7
Total[5]	964 [6]	116,669	143,715	664 [6]	83,693	97,638
Puerto Rico:						
Colombia	4	529	665	5	674	862
Mexico	17	1,981	2,808	14	1,641	2,216
Other	(4) r	14 r	18 r	--	--	--
Total[5]	21	2,525	3,491	19	2,315	3,078
Grand total[5]	985 [6]	119,194	147,206	683 [6]	86,008	100,715

r Revised. -- Zero.

[1] Customs value. The price actually paid or payable for merchandise when sold for exportation to the United States, excluding U.S. import duties, freight, insurance, and other charges incurred in bringing the merchandise to the United States.

[2] Cost, insurance, and freight. The import value represents the customs value plus insurance, freight, and other delivery charges to the first port of entry.

[3] Values of less than $90.00 (c.i.f.) per metric ton likely indicate the mistaken total or partial inclusion of data for gray portland or similar cement or clinker. This error happens when the importer records the wrong tariff number with the U.S. Customs Service. Values that exceed $200 per ton likely indicate misidentified specialty cement, not white cement.

[4] Less than ½ unit.

[5] Data may not add to totals shown because of independent rounding.

[6] Total imports of white cement include substantial quantities of gray cement that were misregistered by importers under the white cement tariff code.

Source: U.S. Census Bureau.

TABLE 21

U.S. IMPORTS FOR CONSUMPTION OF CLINKER, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2008			2009		
		Value			Value	
Country	Quantity	Customs[2]	C.i.f.[3]	Quantity	Customs[2]	C.i.f.[3]
United States:						
Canada	477	35,048	35,310	489	30,192	30,459
China	19	3,414	4,285	3	709	855
Colombia	16	446	718	--	--	--
Egypt	2	149	244	3	318	337
France	107	20,976	23,550	62	19,571	20,732
Other	(4)	21	33	--	--	--
Total[5]	621	60,054	64,141	556	50,789	52,383

-- Zero.

[1] For all types of hydraulic cement.

[2] Customs value. The price actually paid or payable for merchandise when sold for exportation to the United States, excluding U.S. import duties, freight, insurance, and other charges incurred in bringing in the merchandise to the United States.

[3] Cost, insurance, and freight. The import value represents the customs value plus insurance, freight, and other delivery charges to the first port of entry.

[4] Less than ½ unit.

[5] Data may not add to totals shown because of independent rounding.

Source: U.S. Census Bureau.

TABLE 22
HYDRAULIC CEMENT: WORLD PRODUCTION, BY COUNTRY[1,2]

(Thousand metric tons)

Country	2005	2006	2007	2008	2009[e]
Afghanistan[e]	60	50	50	50	50
Albania	489	525	889	737[r]	740
Algeria	12,800	14,702	15,886	17,398[r]	18,000
Angola	1,315	1,373	1,400[e]	1,780[r]	1,800
Argentina	7,595	8,929	9,602	9,703	10,000
Armenia	605	625	722	770	750
Australia[e]	8,475[r,3]	9,000	9,500[r]	9,000[r]	8,500
Austria	4,560	4,852	5,203	5,309	4,600
Azerbaijan	1,538	1,622	1,691[r]	1,595[r]	1,283[3]
Bahrain	400	400	400	438[r]	800
Bangladesh[e]	5,100	5,100	5,100	5,000	5,000
Barbados	341	338	294	300[e]	300
Belarus	3,131	3,495	3,820[e]	4,219	4,350[3]
Belgium	7,594	8,192	8,200[e]	8,200[e]	8,200
Benin[e]	250	1,489[3]	1,550[3]	1,500[r]	1,500
Bhutan[e]	170	180	180	180[r]	180
Bolivia	1,440	1,636	1,739	1,985[r]	2,292[3]
Bosnia and Herzegovina	1,026	1,226	1,283	1,406	1,074[3]
Brazil	38,705[r]	41,895[r]	46,551[r]	51,970[r]	51,748[p,3]
Brunei[e]	266[3]	240	200	240[r]	220
Bulgaria	3,618	4,093	4,413	4,903[r]	2,662[3]
Burkina Faso[e]	30	30	30	30	30
Burma[4]	543	570	608	676	670[3]
Cambodia	--	--	87	772[r]	774[3]
Cameroon[e]	1,000	1,000	1,000	1,000	1,000
Canada	14,179	14,336	15,078	13,672	10,985[3]
Chile	3,999	4,112	4,440	4,622	3,876[3]
China	1,068,850	1,236,770	1,361,170	1,400,000[r]	1,629,000[p,3]
Colombia	9,959	10,038[5]	11,068[5]	10,456[5]	10,000
Congo (Brazzaville)[e]	100[3]	100	100	100[r]	100
Congo (Kinshasa)	521[r]	519[r]	530[r]	411[r]	444[3]
Costa Rica	2,000[r,e]	1,900[r]	2,300[r]	2,500[r]	2,500
Côte d'Ivoire[e]	650	650	650	650	650
Croatia	3,481	3,598	3,587[r]	3,637[r]	2,800
Cuba	1,567	1,705	1,805	1,707[r]	1,700
Cyprus	1,805	1,786	1,873	1,870[e]	1,800
Czech Republic	3,978	4,239	4,899	4,710[r]	3,637[3]
Denmark	2,120	2,115	2,100[e]	2,100[e]	2,000
Dominican Republic	2,779	3,777	4,100[e]	4,000[e]	3,000
Ecuador	3,690	4,110	4,420	5,493[r]	5,000
Egypt	32,458	36,200	38,400	40,000[e]	46,500
El Salvador	1,131	1,311	1,300[e]	1,300[e]	1,300
Eritrea[e]	45	45	45	45	45
Estonia	726	849	937	808	326[3]
Ethiopia	1,569	1,731[r]	1,626[r]	1,834[r]	2,300
Fiji[e]	143[3]	143	145	143	110
Finland	1,357	1,685	1,743	1,745	1,750
France	21,277	22,540	22,300[e]	21,700	18,300
French Guiana[e]	60	60	60	62	62
Gabon[e]	260	260	229[3]	230	230
Georgia[e]	450	450	450	450	450

See footnotes at end of table.

TABLE 22—Continued
HYDRAULIC CEMENT: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2005	2006	2007	2008	2009[e]
Germany	31,009	33,630	33,382	33,581	30,441 [3]
Ghana[e]	1,800 [r]	1,800 [r]	1,800 [r]	1,800 [r]	1,800
Greece	15,166	15,674	16,667	16,500 [e]	16,000
Guadeloupe[e]	240	230	230	230	230
Guatemala[e]	2,400	2,500	2,500	2,500	1,500
Guinea[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
Haiti[e]	300	300	300	300	300
Honduras[e]	1,384 [3]	1,800	1,800	1,800	1,800
Hong Kong[e]	1,005 [3]	1,010	1,000	1,000	1,000
Hungary	3,371	3,724	3,552	3,544	3,200
Iceland	132	141	90 [e]	100 [e]	100
India[e]	145,000	160,000	170,000	185,000 [r]	205,000
Indonesia[e]	33,917 [3]	35,000	36,000	36,000 [r]	40,000
Iran[e]	32,650 [3]	35,300	41,000 [r]	44,400 [3]	50,000
Iraq[e]	3,000	3,500	4,500	6,453 [r, 3]	8,000
Ireland	5,083	4,981	5,000	5,000 [e]	5,000
Israel	5,093	5,089	5,000 [e]	4,819 [r]	4,759 [3]
Italy	40,284	47,814	47,542	43,030	36,317 [3]
Jamaica	845	761	592	725 [r]	700
Japan	69,629	69,942	67,685	62,810	54,800 [3]
Jordan	4,046	3,967	4,051	4,375 [r]	5,000
Kazakhstan	3,975	4,880	5,699	5,223	5,000
Kenya	2,123	2,174	2,546	2,829 [r]	3,320 [3]
Korea, North[e]	5,700	6,160	6,130	6,415 [r, 3]	6,400
Korea, Republic of	51,391	53,971	52,182 [r]	51,653 [r]	50,127 [3]
Kosovo[6]	450	450 [e]	470	590	600
Kuwait[e]	2,145 [3]	2,200	2,200	2,200	2,000
Kyrgyzstan	973 [r]	1,060 [r]	1,230 [r]	1,218 [r]	1,100
Laos[e]	250	400	400	400	400
Latvia[e]	280	280	300	310	300
Lebanon	4,600	4,400	4,900 [e]	5,000 [e]	5,000
Liberia	144	155	157	94 [r]	95
Libya	3,621	5,300 [e]	5,206	5,509 [r]	6,000
Lithuania	832	1,065	1,105	1,100 [e]	1,100
Luxembourg[e]	760 [3]	800	780	780	780
Macedonia	887 [r]	924 [r]	945 [r]	916 [r]	909 [3]
Madagascar[e]	150	150	270 [3]	270	240
Malawi	166	188	185	240 [e]	240
Malaysia	17,860	18,400 [e]	19,480	19,000 [r, e]	18,500
Martinique[e]	220	220	220	220	220
Mauritania	300 [e]	374	410	446 [r]	500
Mexico	37,452	40,362	40,670	47,609	35,160 [3]
Moldova	641	837	800 [e]	750 [e]	700
Mongolia	112	141	180 [r]	269 [r]	140
Morocco[e]	11,000	11,000	11,000	11,000	12,000
Mozambique[e]	490	600	800	730	830
Nepal[e, 4]	290	295	300	295 [r]	300
Netherlands	2,496	2,790	2,700 [e]	2,700 [e]	2,700
New Caledonia	119	133	134 [e]	134 [e]	130
New Zealand[e]	1,100	1,120 [3]	1,100	1,100	1,100
Nicaragua[e]	530 [3]	530	530	530	530

See footnotes at end of table.

TABLE 22—Continued
HYDRAULIC CEMENT: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2005	2006	2007	2008	2009[e]
Niger[e]	59 [r]	83 [r]	62 [r]	42 [r]	40
Nigeria[e]	2,700	3,300	4,700	5,000	4,500
Norway	1,613	1,695	1,700 [e]	1,700 [e]	1,650
Oman	2,686	3,611	3,880	3,991 [r]	4,000
Pakistan[e]	17,000	20,652 [3]	27,000 [r]	31,000 [r]	32,000
Panama[e]	1,050 [3]	1,050	1,050	1,050	1,050
Paraguay[e]	550	600	600	600	600
Peru	5,107	5,782	6,231	6,922	6,862 [3]
Philippines	15,494	12,033	13,048	13,369 [r]	14,865 [3]
Poland	12,646	14,688	17,120	17,207	15,537 [3]
Portugal	8,438	8,340	12,631	12,650 [r]	12,700
Qatar	1,500	1,568	2,500 [e]	3,500 [e]	4,150
Réunion[e]	380	400	400	400	375
Romania	7,032	8,253	10,000 [r, e]	11,000 [r, e]	7,800
Russia	48,500	54,700	59,900	53,600	44,300 [3]
Rwanda	101	103	103	103 [r]	100
Saudi Arabia	26,064	27,056	30,369	31,823	40,000
Senegal	2,623	2,884	3,152	3,084 [r]	3,000
Serbia[7]	2,276 [8]	2,565	2,677	2,843	2,232 [3]
Sierra Leone	172	234	236	254 [r]	250
Slovakia	3,499	3,593	3,718	4,157	3,011 [3]
Slovenia	1,114	1,269	1,300 [e]	1,300 [e]	1,000
South Africa, sales[9]	11,464	12,658	13,651	13,341	11,500
Spain, including Canary Islands	50,347	54,033	54,720	42,088	29,505 [3]
Sri Lanka[e]	1,500	1,600	1,700	1,800	1,900
Sudan	331	202	326	370 [r, e]	1,000
Suriname[e]	65	65	65	65	65
Sweden	2,709	2,952	2,950	2,900 [e]	2,950
Switzerland	4,022	4,040	4,000 [e]	4,000 [e]	4,000
Syria	4,700 [e]	4,804	5,104	5,336	5,605 [3]
Taiwan	19,891	19,294	18,957	17,330	15,918 [3]
Tajikistan	253	282	313	190 [r]	190
Tanzania	1,366	1,370 [r]	1,630 [r]	1,756 [r]	1,700
Thailand	37,872	39,408	35,668	31,651 [r]	31,181 [3]
Togo[e]	800	800	800	800	800
Trinidad and Tobago	686	883	1,992 [r]	958 [r]	950
Tunisia	6,691	6,932	7,052	7,559	8,000
Turkey	42,787	47,499	49,553	54,027 [r]	53,973 [3]
Turkmenistan[e]	650	800	900	900	900
Uganda[e]	630	630	650	650	650
Ukraine	12,183	13,732	15,000	14,918	9,496 [3]
United Arab Emirates[e]	10,000 [r]	11,000 [r]	12,000 [r]	13,200 [r]	16,000
United Kingdom	11,216	11,471 [r]	11,887 [r]	10,071 [r]	7,622 [3]
United States, including Puerto Rico[10]	100,903	99,712	96,850	87,610	64,864 [3]
Uruguay[e]	620	620	620	620	620
Uzbekistan	5,068	5,700 [e]	6,500	6,600 [e]	6,600
Venezuela[e]	5,800	7,200	9,000	9,000	9,000
Vietnam	30,808	32,690	37,102 [r]	40,009 [r]	47,900
Yemen	1,550	1,470	1,728	3,000 [e]	4,000
Zambia[e]	435	650	650	700	600

See footnotes at end of table.

TABLE 22—Continued
HYDRAULIC CEMENT: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2005	2006	2007	2008	2009[e]
Zimbabwe[e]	600	700	400	400	300
Total	2,350,000	2,610,000	2,810,000	2,850,000 [r]	3,040,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown. Even where presented unrounded, reported data are thought to be accurate to no more than three significant digits. Data are from a variety of sources, including the European Cement Association.

[2] Table includes data available through July 23, 2010. Data may include clinker exports for some countries.

[3] Reported figure.

[4] Data are for fiscal year ending March 31 of the following year.

[5] Data for 2006–08 are for gray cement only; white cement output was likely to have been an additional 50,000 to 100,000 tons per year.

[6] Not included in Serbia data.

[7] Excludes Kosovo data.

[8] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union. Montenegro has no cement plants.

[9] Data have been adjusted to remove sales of cementitious materials other than finished cement. Material sales removed (mostly fly ash and ground granulated blast furnace slag) amounted, in metric tons, to: 2005—1,511,716; 2006—1,599,505; 2007—1,664,304; 2008—1,395,124; and 2009—1,200,000 (estimated).

[10] Portland and masonry cements only.

CHROMIUM

By John F. Papp

Domestic survey data and tables were prepared by Lisa Mersdorf, statistical assistant, and the world production tables were prepared by Glenn J. Wallace, international data coordinator.

In 2009, the U.S. chromium supply (measured in contained chromium) was 141,000 metric tons (t) from recycled stainless steel scrap, 273,000 t from imports, and 162,000 t from Government and industry stocks. Supply distribution was 280,000 t to exports, 136,000 t to Government and industry stocks, and 160,000 t to apparent consumption. Chromium apparent consumption decreased by 63.0% compared with that of 2008. Historically, chromium ferroalloys have replaced chromite ore as the leading source of chromium to the U.S. economy. Stainless steel mill products have been accounting for an increasing share of chromium supply to the domestic economy, now rivaling that of ferrochromium. Because stainless steel mill products contribute a significant amount of chromium to the domestic economy, trade in these products has been incorporated into chromium trade statistics, and their contribution has been accounted for in chromium apparent consumption.

Domestic Data Coverage

Domestic data for chromium materials were developed by the U.S. Geological Survey (USGS) by means of the monthly "Chromite Ores and Chromium Products" and "Consolidated Consumers" consumer surveys. Stainless and heat-resisting steel producers are the leading chromium consumers, and high-carbon ferrochromium is the leading chromium-containing material consumed.

Legislation and Government Programs

The Defense National Stockpile Center (DNSC) disposed of chromium materials under its fiscal year 2009 (October 1, 2008, through September 30, 2009) Annual Materials Plan (AMP) and announced the fiscal year 2010 plan. The DNSC's fiscal year 2010 AMP set maximum disposal goals for chromium materials at 90,700 t of chromium ferroalloys and 907 t of chromium metal (Defense National Stockpile Center, 2009).

Production

The major marketplace chromium-containing materials are chromite ore and foundry sand; chromium chemicals, ferroalloys, and metal; and stainless steel. In 2009, the United States produced chromium chemicals, ferroalloys, and metal, and stainless steel. The United States is a major world producer of chromium chemicals, chromium metal, and stainless steel.

Industrial Minerals Corp. Ltd. (Australia) (IMC) conducted the Oregon Resources Project (ORP) to recover chromite from its paleo-beach placer (heavy-mineral sand) deposits in Coos County, OR. IMC reported proved chromite ore reserves of 7,876,847 t at an average grade of 7.50% Cr_2O_3. IMC planned to start construction of the main processing facilities at Coos Bay (Industrial Minerals Corp. Ltd., 2010, p. 10–13).

Eramet Marietta produced chromium metal and ferrochromium at its Marietta, OH, plant. Eramet produced chromium metal via the electrolytic process, with a production capacity of about 3,000 metric tons per year (t/yr).

The U.S. stainless steel industry produces more than 2 million metric tons per year (Mt/yr) of stainless steel and imports and exports stainless steel mill products and scrap, which account for a significant amount of chromium in U.S. trade. The stainless steel industry is the leading consumer of chromium materials. AK Steel Corporation, Allegheny Technologies Incorporated (ATI), and North American Steel Co. were the leading U.S. stainless steel producers.

AK Steel produced stainless steel at Butler, PA, and Mansfield, OH. AK Steel reported shipments of 608,000 t stainless and electrical steel in 2009 compared with 868,300 t in 2008 (AK Steel Corporation, 2010, p. 9, 16). ATI produced stainless steel at Brackenridge, Midland, Natrona, and Latrobe, PA. ATI reported production of 381,991 t of high value and standard stainless steel products in 2009 compared with 492,041 t in 2008 (Allegheny Technologies Incorporated, 2010, p. F15, F28).

ThyssenKrupp Stainless USA [a subsidiary of ThyssenKrupp AG (Germany)] reported progress in the construction of a stainless steel plant at Calvert, AL. The new plant would have a stainless steel melt shop production capacity of 1 Mt/yr of slabs. Construction started in 2007, and the plant was to be completed in 2010 (ThyssenKrupp AG, 2009, p. 84).

North American Stainless (NAS) [a subsidiary of Acerinox, S.A. (Spain)] produced stainless steel in Ghent, KY. NAS reported melt shop production at 682,235 t in 2009 compared with 709,326 t in 2008. NAS completed startup of the No. 4 annealing and pickling line and began operation of the No. 5 cold rolling mill. NAS added new cutting lines at its service centers in Wrightsville, PA, and Monterrey, Mexico (Acerinox S.A., 2010, p. 177–179).

Didaleusky and others (2010) documented the 1987–2007 decline of bulk ferroalloy companies, plants, and production in North America, noting that a decrease of ferrochromium production was clearly observed as early as 1970.

Environment

The U.S. Environmental Protection Agency (EPA) regulates chromium releases to the environment and reports on any such releases (U.S. Environmental Protection Agency, 2010). The Occupational Safety and Health Administration (OSHA) regulates workplace exposure to chromium (Occupational Safety and Health Administration, 2010).

OSHA (2009) published a booklet about hexavalent chromium [Cr(VI)] intended to provide information for general industry standards (29 CFR 1910.1026), shipyards (29 CFR 1915.1026), and construction (29 CFR 1926.1126). The booklet also discusses exposure, hygiene, housekeeping, regulations, and other related topics. OSHA reported that Cr(VI) is a toxic form of the element chromium. Cr(VI) is used in pigments, metal finishing (electroplating), wood preservatives and fungicides, and in chemical synthesis as an ingredient and catalyst; however, it is rarely found in nature and is generally synthetic. Cr(VI) may be present in fumes generated during the production or welding of chromium-containing alloys. Chromium metal is often alloyed with other metals or plated on metal and plastic substrates to improve corrosion resistance and provide protective coatings. The steel industry is a major consumer of chromium in the production of stainless steel.

Prices

Chromium materials are not openly traded. Purchase contracts are confidential between buyer and seller; however, trade journals report composite prices based on interviews with buyers and sellers, and traders declare the value of materials they import or export. Thus, industry publications and U.S. trade statistics are sources of chromium material prices and values, respectively.

The average South African Rand exchange rate is a potentially significant factor in the price of chromite ore and ferrochromium because South Africa is a leading producer of these materials. The South African Rand exchange rate decreased to a time-weighted average of R8.43 per U.S. dollar in 2009 from R8.27 per U.S. dollar in 2008 (Pacific Exchange Rate Service, 2010). From 2001 through 2006, the change in U.S. dollar per Rand coincided with the change in U.S. import value of high-carbon ferrochromium; however, in 2007 and 2008 the Rand per U.S. dollar and the import value of high-carbon ferrochromium increased. Coincident change returned in 2009. Expansion of the Chinese economy and that of India were thought to have been the leading influences causing chromium prices to increase from 2007 through part of 2008 until the global financial crisis in late 2008 caused those prices to decline. The drop in mass-weighted average import value of high-carbon ferrochromium from 2008 to 2009 was thought to have resulted from the global economic crisis of 2008.

Foreign Trade

Chromium-containing material exports from and imports to the United States included chromite ore; chromium chemicals, ferroalloys, metal, and pigments; and stainless steel. Based on foreign trade statistics collected by the U.S. Department of the Treasury and reported by the U.S. Department of Commerce for calendar year 2009, the value of foreign trade of these chromium materials excluding stainless steel mill products and scrap was $87 million for exports and $444 million for imports. A significant amount of chromium exits and enters the U.S. economy via stainless steel mill product and scrap trade. The value of foreign trade of chromium materials including stainless steel mill products and scrap was $2,320 million for exports and $2,290 million for imports (table 1).

World Industry Structure

The chromium industry comprises chromite ore, chromium chemicals and metal, ferrochromium, stainless steel, and chromite refractory producers. Several trends are simultaneously taking place in the chromium industry. The chromium chemical industry has eliminated excess production capacity, concentrating on production growth in surviving plants. Chromite refractory use has been declining; however, foundry use has been increasing slowly. Environmental concerns have reduced the use of chromite refractories and chromium chemicals. The fraction of chromite ore from independent producers is declining, while that from vertically integrated producers is increasing. In other words, chromite ore mines tend now to be owned and operated by chromite refractory, chromium chemical, or ferrochromium producers. This trend is associated with the migration of ferrochromium production capacity from stainless steel producing countries to chromite ore-producing countries, a trend that has been interrupted with the emergence of China as a significant ferrochromium and leading stainless steel producer. While ferrochromium production capacity was closed in historically producing countries, which usually have been stainless steel-producing countries, new furnaces or plants were constructed in chromite ore producing areas. The electrical power and submerged-arc electric-furnace production capacities used to produce ferrochromium have been increasing. Furnaces built recently have an electrical capacity in the tens of megavoltamperes (MVA), whereas when ferrochromium plants were first built, furnaces rated in the low kilovoltampere (kVA) range were common.

Production process improvements, such as agglomeration of chromite ore, preheating and prereduction of furnace feed, and closed-furnace technology, have been retrofitted at the plants of major producers and are being incorporated in newly constructed plants. Since the introduction of post-melting refining processes in the steel industry after 1960, there has been a shift in production to high-carbon ferrochromium from low-carbon ferrochromium. After years of ferrochromium production, slag stockpiles have grown. Recently developed processes have efficiently recovered ferrochromium from that slag, and processes have been or are being installed at existing plant sites. In South Africa, the leading chromite ore- and ferrochromium-producing country, three trends are emerging—ferrochromium plants are being developed in the western belt of the Bushveld Complex, ferrochromium plants are being built in association with chromite ore mines, and ferrochromium production processes have been developed to accommodate chromite ore byproduct recovered from platinum operations.

Capacity.—Rated capacity is defined as the maximum quantity of product that can be produced in a period of time at a normally sustainable long-term operating rate based on the physical equipment of the plant and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that can be brought into production within a short period of time with minimum capital expenditure. Because not all countries or producers provide information about production capacity, historical chromium trade data also have been used to estimate national production capacities. Reported production capacity changes result from both facility changes and increased knowledge about facilities. New information about a facility may result in the reevaluation of production capacity for that facility. Production capacities have been rated for the chromite ore, chromium chemical, chromium metal, ferrochromium, and stainless steel industries (table 7).

Production.—In 2009, world chromite ore production was about 18.9 million metric tons (Mt) gross weight, of which 95.2% was produced for the metallurgical industry; 2.4%, for the foundry industry; 1.6%, for the chemical industry; and 0.8%, for the refractory industry (International Chromium Development Association, 2010, p. 1).

The chromium industry entered 2009 under the burden of a world economic recession resulting from the world financial crisis of 2008. Demand for chromium declined significantly along with demand for industrial and consumer products that contain chromium. Under conditions of reduced consumption, producers and consumers of chromium-containing materials used stocks as their primary source of supply, exacerbating falling demand. Prices of chromium materials fell, but began to recover before the end of the year. Consumption, however, did not return to 2008 levels.

Chromium Chemicals.—Major chromium chemical producers included China, Russia, South Africa, Kazakhstan, and the United States. Murthy (2009) reported that world sodium dichromate production was about 1.2 Mt produced by China (27%), United States (16%), Kazakhstan (12%), Russia (11%), South Africa (11%), Turkey (9%), and India (8%).

Chromium Metal.—Major chromium metal producers included Russia (by the electrolytic process), Japan (by the silicothermic process) and China, France, Kazakhstan, Russia, and the United Kingdom (by the aluminothermic process). Lofthouse (2009) reported that industrial-scale chromium metal production by the aluminothermic process started in Germany after the process was patented by Hans Goldschmidt in 1922 and by the electrolytic process in the United States after 1950. In 1990, there were 15 industrial scale chromium metal producers, 12 aluminothermic and 3 electrolytic; however, by 2010 there were 7 aluminothermic, 1 electrolytic, and 1 silicothermic chromium metal producers. During the same time period, production shifted from 70% aluminothermic/30% electrolytic in 1990 to 95% aluminothermic in 2010. Chromium metal produced by the aluminothermic process requires metal-grade chromic oxide, a chemical product, as a feed material. The two metal producers in China, Jinzou and Sing Horn, and two of the metal producers in Russia, Kluchevsky and Novotroitsk, are vertically integrated chromic oxide-chromium metal producers. The remaining two aluminothermic chromium metal producers, LSM in the United Kingdom and Delachaux in France, were supplied by Aktyubinsk in Kazakhstan and Elementis in the United Kingdom until it closed in 2009 and then by Elementis in the United States. World production of chromium metal peaked at 40,000 t in 2007, and then declined to 34,000 t in 2008. Nickel- and cobalt-based alloys and superalloys used in aerospace (jet engine) and electrical power (turbine powerplants) were the leading end use for chromium metal.

Stainless Steel.—In 2009, world stainless steel production was 24.579 Mt, a decrease of 5.2% from that of 2008 (International Stainless Steel Forum, 2010). At 36% of world stainless steel production, China was the leading producer in 2009. Pariser (2010, p. 14) reported stainless steel production increased in 2009 from 2008 for Asia excluding China (7.9%) and for China (32.8%). The rest of the world showed mostly double digit declines.

Ferrochromium.—The price of coke, an essential reductant for ferrochromium production, has escalated owing to, in the Western world, stricter environmental regulations and less integrated steel production; in China, which accounted for one-half of world trade in 2009, by export taxes and the closure of bee hive furnaces; and in general by higher prices owing to port and rail investments to alleviate transportation bottlenecks. Jones estimated that coke accounted for 25% of ferrochromium price in 2004 at 25 cents per pound, and for 20% of that price in 2009, assuming 0.6 t of coke per ton of ferrochromium product (Jones, 2010).

Stainless Steel Scrap.—Stainless steel scrap is an important source of chromium to the stainless steel industry that consists of three components: internal (such as, scrap generated in the steelmaking plant), external (such as, scrap that originates outside the steel producing plant), and reclaimed (such as, post-consumer scrap). Stainless steel scrap recycling accounts for a significant, but undocumented, fraction of world stainless steel production. Kovarsky (2009) reported historical stainless steel melting production growth rate (from 1995 to 2008) to have been 5.3% and that of ferrochromium consumption to have been 5.2%. External stainless steel scrap growth during the same period was about 8.1%. China was expected to become the leading stainless steel producer and consumer of stainless raw materials, which would lead to chromium-material markets reflecting Chinese market dynamics. Merrills (2009) reported that historical stainless steel scrap availability increases to about the same rate as stainless steel melting production (5% to 7% per year). Internal stainless steel scrap is recycled within about 3 months; external scrap, within about 6 months; and reclaimed scrap, within about 15 to 20 years. Stainless steel scrap is less costly to consume in the production of stainless steel than primary raw materials and is more environmentally friendly because less carbon dioxide (CO_2) is generated and less energy used when recycled raw materials are used in place of primary raw materials (such as iron and ferroalloy). Asia recently has accounted for most of the growth in stainless steel production and consumption driven mainly by China. As a result, Asia was expected to surpass Europe in stainless steel production and consumption by 2013 and to become a leading source of stainless steel scrap.

World Review

Albania.—ACR (formerly Albanian Chrome) [a subsidiary of DCM (Austria)] produced chromite ore at Bulquiza Mine. DCM DECOmetal [a subsidiary of DCM (Austria)] produced high- and low-carbon ferrochromium at Elbasan (DCM, 2008).

DCM operated three furnaces at Elbasan, two for high-carbon ferrochromium and one for low-carbon ferrochromium. DCM's production capacity was 18,000 t/yr of low-carbon ferrochromium and 18,000 t/yr of high-carbon ferrochromium. DCM planned to increase low-carbon ferrochromium production capacity to 33,000 t/yr (Metal Bulletin Daily, 2009a, b; SBB Daily Briefing, 2009a).

Albanian Minerals & Bytyci Shpk explored for chromite ore in the Tropoje and Kukes areas of northern Albania and Kosovo (International Chromium Development Association Secretariat, 2009).

Empire Mining Corporation (Canada) explored for chromite ore in the Bulqiza chromite mining district near the town of Bulqiza (41°29'27" N, 20°13'4" E). Empire started a drilling program in the area (Empire Mining Corporation, 2009, 2010).

JAB Resources Limited (Australia) explored for chromite ore in the Bregu I Bibes, Kalimash, and Zogaj areas. JAB reported inferred mineral resources of 6.72 Mt grading 4.36% Cr_2O_3 in the Kalimash area (JAB Resources Limited, 2010, p. 63).

Australia.—The Government of Western Australia reported chromite ore sales by calendar year in contained Cr_2O_3: 2008, 56,881 t-Cr_2O_3; 2009, 74,789 t-Cr_2O_3 (Government of Western Australia, 2010, p. 20).

Brazil.—Brazil produced chromite ore, ferrochromium, and stainless steel. Brazil reported 2008 chromite ore production of 705,762 t (299,952 t Cr_2O_3-content), 54,273 t of chromite ore (24,422 t Cr_2O_3-content) exports, and 22,896 t (12,592 Cr_2O_3-content) imports. Brazil produced from a chromite ore reserve of 12.9 Mt containing about 4.469 Mt Cr_2O_3-content, mostly in Bahia State. In 2008, Brazil produced 199,354 t of chromium ferroalloys, exported 34,827 t and imported 11,648 t (Ramos, 2010). Based on production of chromite ore and trade of chromite ore and chromium ferroalloys, Brazilian chromium apparent consumption was 312,000 t in 2008.

Canada.—Canada reported chromium mineral imports of 60,301 kg in 2008, 50,599 kg in 2007; and 49,009 kg in 2006; exports of 1,921 kg in 2008, 1,759 kg in 2007; and 2,733 kg in 2006; 2,991 kg in 2005 (Natural Resources Canada, 2009).

Cliffs Natural Resources Inc. (United States) (2010, p. 5, 115) acquired Freewest Resources Canada Inc. and its chromite ore resources in Ontario, Canada. Cliffs planned to mine from 1 to 2 Mt/yr of chromite ore to produce from 400,000 to 800,000 t/yr of ferrochromium that would subsequently be used to produce alloy or stainless steel.

China.—China produced chromite ore, chromium chemicals and metal, ferrochromium, and stainless steel. China was the leading producer of stainless steel, which also made it the leading market for ferrochromium. China produced a small amount of chromite ore; a moderte amount of ferrochromium, mostly from imported chromite ore; and a large amount of stainless steel.

The Government encouraged power consumers to negotiate prices directly with powerplants without the interference of local authorities. Discounts in electricity prices were expected to be available, but at a smaller discount than before. As a result, electrical power prices were expected to rise for ferrochromium producers (Metal Bulletin Daily, 2009c, p. 1).

China's economy grew by 8.7% in 2009 and inflation was 1.9% year-on-year in December. China's government stimulus measures helped the economy to withstand the global recession. To avoid further inflation, China raised its reserve ratio requirement, which limits the amount banks can lend as a proportion of total reserves (Metal Bulletin Daily, 2010, p. 1).

The leading stainless steel producers in China were Baosteel Stainless, Lianzhong Stainless Steel Corporation, Shanghai Krupp Stainless, Shanxi Taigang Stainless (Taiyuan Iron & Steel), and Zhangjiang Pohang Stainless Steel.

Finland.—Finland produced chromite ore (Kemi Mine) (65°46'55.50" N, 24°42'18.58" E), ferrochromium (Tornio Works), and stainless steel (Tornio Works) (Baerchmann, undated). In 2009, Outokumpu produced 247,000 t of marketable chromite ore from 0.9 Mt of run-of-mine ore and 123,000 t of ferrochromium compared with 614,000 t of chromite ore from 1.3 Mt of run-of-mine ore and 234,000 t of ferrochromium in 2008. The company reported proven reserves of chromite ore at 37 Mt graded at 26% Cr_2O_3, and indicated resources of chromite ore at 13 Mt graded at 30% Cr_2O_3, and inferred resources of chromite ore at 73 Mt graded at 29% Cr_2O_3. Outokumpu produced stainless steel at meltshops in Tornio, Avesta (Sweden), and Sheffield (Britain). Outokumpu reported that its stainless steel comprised 90% recycled materials while the world average is 60%. Outokumpu idled its Kemi Mine, ferrochromium works, and a stainless steel melt shop from April to October owing to weak demand (Outokumpu Ojy, 2010).

Germany.—Germany produced low-carbon ferrochromium and stainless steel. Elektrowerke Weisweiler GmbH produced low-carbon ferrochromium and ThyssenKrupp AG produced stainless steel. Elektrowerke Weisweiler was owned by Kermas Group (United Kingdom). Kermas also owned Serov Ferroalloys Plant (Russia) and Samancor (South Africa), other low-carbon ferrochromium producers.

India.—India produced chromite ore, chromium chemicals, ferrochromium, and stainless steel. India exported lumpy and friable chromite ore and chromite ore concentrates. India reported that 21 mines collectively produced 4,798,515 t of chromite ore in fiscal year 2007–08 (April 1, 2007, through March 31, 2008) from a chromite ore reserves of 66.128 Mt compared with 5,295,551 t from 17 mines in fiscal year 2006–07. India reported chromite ore exports of 906,575 in fiscal year 2007–08, 1,203,060 in fiscal year 2006–07, and 692,673 t in fiscal year 2005–06 (Indian Bureau of Mines, 2009). Kapure and others (2010) estimated that 140 Mt of chromite overburden had been mobilized in India and that 5 Mt is generated each year. The chromite overburden contains 0.6% to 0.8% nickel in addition to chromium and iron. The authors recovered about 80% of chromium, iron, and nickel from chromite overburden in bench-scale tests by direct reduction using coal.

The leading Indian chromite ore producers were OMC Ltd. and Tata Iron and Steel Corp. (Metal Bulletin Daily, 2009e). Orissa Mining Corp. operated the Daitari and Kaliapani Mines (OMC Ltd., undated). Ferro Alloys and Minerals (FAMD), a division of Tata Iron and Steel Corp., produced chromite ore in the Jajpur District of Orissa State. FAMD beneficiated its ore at its beneficiation plant in Sukinda and then exported the product or converted it to ferrochromium at its plants in Keonjar District and Cuttack, Orissa State. At Cuttack, FAMD operated two furnaces with electrical power rating of 16.5 MVA and ferrochromium production capacity of 50,000 t/yr. At Bamnipal, FAMD operated one furnace with electrical power rating of 33.5 MVA and ferrochromium production capacity of 60,000 t/yr (Ferro Alloys and Minerals Division, undated).

Balasore Alloys Limited, formerly Ispat Alloys Limited, a part of the Ispat Group produced chromite ore and ferrochromium. Balasore operated chromite ore mines in Sukinda Valley, Jajpur, Orissa. Balasore planned to set up a captive electrical powerplant and to expand beneficiation, furnaces, and transportation (Balasore Alloys Limited, 2010, p. 10).

OMC suspended mining operations for about 2 weeks in September while it resolved a forest clearance with the State Forest Department, after which OMC was ordered by the State of Orissa to stop supplying chromium ore to ferrochromium producers outside the State of Orissa for the December quarter (Metal Bulletin Daily, 2009f, g).

Idcol Ferro Chrome & Alloys planned to build a chromite ore beneficiation plant. The company's ferrochromium plant in Jajpur, Orissa State, has a production capacity of 25,000 t/yr of high-carbon ferrochromium from a captive ore supply. The plant also produced low-carbon ferrochromium (Metal Bulletin Daily, 2009d).

JSL Limited (formerly Jindal Stainless) produced chromite ore, ferrochromium, and stainless steel. JSL operated a 40,000-t/yr ferrochromium plant at Vizag and a 150,000-t/yr ferrochromium plant in Orissa. JSL's chromite ore division produced 3,946 t of chromite ore and 22,833 t of chrome ore concentrate. JSL commissioned a chromite ore beneficiation plant in August. JSL's Vizag, Andra Pradesh, plant produced 32,681 t of high-carbon ferrochromium in 2009 compared with 31,901 t in 2008. JSL continued construction of a 1-Mt/yr stainless steel plant in Jajpur, Orissa (JSL Limited, 2010, p. 11, 17, 35).

Ferro Alloys and Minerals Division of Tata Steel Limited produced ferrochromium at its Bamnipal plant in fiscal year 2009–10 (April 1 through March 31) (Tata Steel Limited, 2010, p. 75, 137).

Facor Alloys Limited produced 63,350 t of ferrochromium in 2008–09 compared with 69,075 t in 2007–08 at its Garividi Plant, Andhra Pradesh (18°16′25″ N, 83°32′ E) (Facor Alloys Limited, 2009, unpaginated; Prakash, 2010).

Ferro Alloys Corporation Limited produced 177,760 t of chromite ore and 56,216 t of high-carbon ferrochromium in FY 2008–09 compared with 186,896 t of ore and 53,750 t of ferrochromium in 2007–08. Ferro Alloys Corporation produced ferrochromium at Charge Chrome Plant, Randia, Orissa, and mined chromite ore, also in Orissa (Ferro Alloys Corporation Limited, 2009, p. 20).

Indian Metals and Ferro Alloys Limited (IMFA) mined chromite ore in Orissa and produced ferrochromium at Choudwar and Therubali plants. IMFA mined 282,836 t of chromite ore and produced 130,758 t of ferrochromium (Indian Metals and Ferro Alloys Limited, 2009, p. 7, 8, 13). IMFA planned to expand production of high-carbon ferrochromium at Choudwar plant with the addition of a 30 MVA furnace to the existing two furnaces by 2010. The expansion would increase IMFA's total production capacity to 275,000 t/yr. IMFA exported about 75% of its ferrochromium production, mainly to China, Japan, and Republic of Korea. The company also operated three chromite ore mines in Orissa and had a captive powerplant at the Choudwar works (SBB Daily Briefing, 2009c).

Rohit Ferro-Tech Limited produced ferrochromium at Jajpur, Orissa, and Dishnupur, West Bengal (Rohit Ferro-Tech Limited, 2009, p. 4, 18).

Jindal (2009) reported that more than three-fourths of India's stainless steel production is 200 series and that production capacity in 2009 was 2.910 Mt; production was 2.1 Mt. Ferrochromium production capacity was 1.3 Mt.

Murthy (2009) reported that sodium dichromate production capacity in India amounted to 88,000 t/yr of which Vishnu Chemicals Limited accounted for 70,000 t/yr.

Kazakhstan.—Eurasian Natural Resources Corporation PLC (ENRC) (United Kingdom) produced chromite ore and ferrochromium. ENRC produced chromite ore at Donskoy and Saranovskaya Mines. Production capacity at Donskoy was 3.5 Mt/yr from 184.2 Mt of reserves at an average grade of 41.5% Cr_2O_3; Saranovskaya production was 150,000 t/yr. ENRC produced ferrochromium at Aksu (800,000-t/yr ferrochromium production capacity), Aktobe (368,000-t/yr ferrochromium production capacity), and Serov (195,000-t/yr ferrochromium production capacity) plants. ENRC reported production with 1.161 Mt ferrochromium in 2009 compared with 1.196 Mt in 2008. ENRC constructed a second 700,000-t/yr pelletizing plant at a cost of $40 million and worked on installation of a direct current furnace at Aktobe with production capacity of 440,000 t/yr that was to be completed in 2012 at a cost of $590 million. The new production capacity was to displace a portion of the old production capacity, which was to be retired (Eurasian Natural Resources Corporation PLC, 2009, p. 10; 2010, p. 14–16, 45).

Chromite ore commercial reserves were 317.2 Mt at an average grade of 45.9% Cr_2O_3 of which 24.8 Mt at 41.4% Cr_2O_3 could be surface mined and the remaining 292.4 Mt at 50.7% Cr_2O_3 could be mined by underground methods. In 2008, TNK Kazchrome (a subsidiary of ENRC in Aktobe) produced 1.07 Mt of chromium ferroalloys; 996,267 t of high-carbon ferrochromium; 45,496 t of medium-carbon ferrochromium; and 32,914 t of low-carbon ferrochromium (Tolymbekov and others, 2010).

Russia.—Russia produced chromite ore, chromium metal and chemicals, ferrochromium, and stainless steel. Mechel Open Joint-Stock Company produced chromite ore (Voskhod deposit in Aktyubinsk region of Kazakhstan), ferrochromium (Tikhvin Ferroalloy Smelting Plant Closed Joint-Stock Company, Leningradskaya region), and stainless steel. Mechel reported production of 58,000 t of ferrochromium in 2008 (Mechel Open Joint-Stock Company, 2009, p. 6, 10). Russia also produced ferrochromium at Serov and ferrochromium and chromium metal at Kluchevsky Ferroalloy Plant.

Russia increased ferrochromium production to 578,000 t in 2005 from 274,000 t in 2000 based mostly on chromite ore imported from Kazakhstan, Turkey, and other countries. Russia mined chromite ore in the Urals (Saranovskoe, Alapaevskoe, and others) and in the Komi region; however, the ore was low grade. Saranovskoe chromite ore was used in Serov Ferroalloys Plant, JSC (Leontyev and Zhuchkov, 2010).

South Africa.—South Africa was a leading chromite ore and ferrochromium producing country and produced chromium chemicals and stainless steel.

AMCOL International Corporation (United States) purchased 53% interest in the Ruighoek Chrome Project from Pacific Niugini Limited [formerly Chrome Corporation Limited (Australia)] citing strong demand for specialized grade chromite within the heavy-casting industry (AMCOL International Corporation, 2010, p. 4). AMCOL took operational control of Ruighoek Chrome Project in the Western Lobe of the Bushveld Igneous Complex in North West Province of South Africa, where chromite has been mined for more than 50 years. AMCOL planned to mine chromite ore from the LG6 and LG6A seams first by surface and then by underground methods (Chrome Corporation Ltd., 2010, p. 6).

African Rainbow Minerals Ltd. (ARM) produced chromite ore and ferrochromium in joint-venture partnerships with Assmang Ltd. (Dwarsrivier Chrome Mine and Machadodorp Ferrochrome Works) and with Norilsk Nickel Africa (Nkomati Nickel and Chrome Mine). Nkomati Nickel Mine produced 528,000 t of chromite ore in fiscal year 2009 compared with 1,177,000 t in 2008 and 631,000 in 2007. Nkomati chromite ore proven and probable reserves reportedly were 2.9 Mt at 31.0% Cr_2O_3; measured and indicated resources were 1.8 Mt at 33.6% Cr_2O_3. Dwarsrivier Chrome Mine production was 684,000 t in fiscal year 2009 compared with 849,000 t in 2008, 710,000 Mt in 2007, and 526,000 t in 2006. Dwarsrivier proven and probable reserves were 39.6 Mt at 39.5% Cr_2O_3; measured and indicated resources were 53.2 Mt at 39.56% Cr_2O_3. Machadodorp ferrochromium production was 169,000 t in 2009 compared with 270,000 t in fiscal year 2008, 242,000 t in 2007, and 230,000 t in 2006 (African Rainbow Minerals Ltd., 2009, p. 35, 48).

Assore Ltd. produced chromite ore at Zeerust Chrome Mines Ltd. and chromite ore and ferrochromium in joint-venture partnership with ARM [Dwarsrivier Chrome Mine (30°05′00″ E, 24°59′00″ S), Machadodorp Ferrochrome Works] through its subsidiary company Rustenburg Minerals Development Company (Proprietary) Ltd. (RMDC). RMDC developed shafts to mine underground as surface reserves diminished. Zeerust chromite ore proven reserves were 0.8 Mt; measured and inferred resources were 0.9 Mt and 10.6 Mt, respectively (Assore Ltd., 2010, p. 7, 20, 29).

ASA Metals (Pty.) Ltd. (24°33’ S, 30°08’35” E) (Pentz, undated a) [a joint venture between Sinosteel Corp. (China) and Limpopo Economic Development Enterprise] produced chromite ore and ferrochromium. ASA installed two 66-MVA furnaces and a beneficiation and pelletizing plant to process feed material for ASA’s furnaces. ASA increased its ferrochromium production capacity to 400,000 t/yr (ASA Metals (Pty.) Ltd., undated). ASA operated four furnaces; two rated at 66 MVA, one at 45 MVA, and one at 33 MVA with a collective annual ferrochromium production capacity of 240,000 t/yr. The beneficiation and pelletizing plant production capacity was 600,000 t/yr of pellets comprised of chromite ore concentrate, UG2 chromite concentrate, smelter dust, fine coke, and bentonite. The pellets contained 41.4% Cr_2O_3 and were smelted into ferrochromium product containing 50.5% chromium (Ives, 2009).

Chromex Mining plc (United Kingdom) operated the Stellite opencast mine in the western limb of the Bushveld Complex. A processing facility designed to take 40,000 metric tons per month of run-of-mine ore was completed in 2009, and production of chromite ore graded at 42% to 44% Cr_2O_3 was started (Chromex Mining plc, 2010).

Hernic Ferrochrome (Pty.) Ltd. produced chromite ore and ferrochromium. Hernic produced chromite ore at its Maroelabult Mine and started development of Bokfontein Mine, which was planned to produce 1.5 Mt/yr of chromite ore. Hernic reported chromite ore reserves of 250 Mt and production capacity of 420,000 t/yr (Hernic Ferrochrome (Pty.) Ltd., 2007).

International Ferro Metals Ltd. (Australia) (IFM) produced chromite ore at Lesedi Mine and ferrochromium at its integrated works in the western limb of the Bushveld Complex. IFM developed the SkyChrome property in which it held 80% interest. IFM reported Lesedi plus SkyChrome proven and probable reserves of 55.359 Mt at 32% Cr_2O_3 and measured and indicated resources of 102.553 Mt at 32.49% Cr_2O_3. In the fiscal year that ended in June, IFM reported ferrochromium production of 110,346 t from a production capacity of 267,000 t/yr (International Ferro Metals Ltd., 2009, p. 2, 7, 25).

Merafe Resources Ltd. produced chromite ore and ferrochromium via wholly owned subsidiary companies and in joint venture with Xstrata plc. In the eastern limb of the Bushveld Complex, Merafe mined chromite ore or produced byproduct chromite at Boshoek, Horizon, Kanana UG2 plant, Kroondal, Marikana, and Waterval Mines and produced ferrochromium at Lydenburg and Lion plants. In the western limb of the Bushveld Complex, Merafe mined chromite ore or produced byproduct chromite at EPL UG2 plant, Helena, Magareng, Mototolo UG2 plant, and Thorncliffe and produced ferrochromium at Boshoek, Rustenburg, and Wonderkop plants. Collectively, these plants had ferrochromium production capacity of 1.979 Mt/yr from 20 furnaces at 5 production sites. Merafe reported run-of-mine production of 3.33 Mt in 2009 from proven chromite ore reserves of 52.078 Mt at an estimated average grade of 33.93% Cr_2O_3 (Merafe Resources Ltd., 2010, p. 3, 75, 78).

Samancor Chrome Ltd. [a subsidiary of the Kermas Group (Virgin Islands)] is the second leading chromite ore and ferrochromium producer in South Africa. Samancor operated two mining complexes (Eastern Chrome Mines, Lydenburg-Steelpoort area, Mpumalanga Province, and Western Chrome Mines, Rustenburg, North West Province) and four ferrochromium plants (Ferrometals, Emalahleni (formerly Witbank), Mpumalanga Province; Middelburg Ferrochrome, Middelburg, Mpumalanga Province; and Tubatse Ferrochrome (24°44’27.55” S, 30°11’45.09” E), Lydenburg-Steelpoort area, Mpumalanga Province (Pentz, undated b; Samancor Chrome Ltd., 2008).

Tata Steel reported production from two 75,000-t/yr furnaces at Richards Bay to have been 118,327 t in financial year

2009–10 (April 1 through March 31) compared with 63,479 t in financial year 2008–2009 (Tata Steel Limited, 2010, p. 80).

Xstrata plc (Switzerland) was the leading world ferrochromium producer. Xstrata produced chromite ore and ferrochromium in South Africa at vertically integrated operations. Xstrata produced 0.786 Mt in 2009 compared with 1.126 Mt of ferrochromium in 2008. Xstrata reported proven reserves of 52 Mt and probable reserves of 17 Mt (Xstrata plc, 2010, p. 53, 93, 173).

Columbus Stainless Pty. Ltd. produced 546,261 t of stainless steel in 2009 compared with 528,336 t in 2008, a 3.4% increase. Columbus worked to optimize its use of liquid ferrochromium to reduce its electrical power needs (Acerinox S.A., 2010, p. 180–181).

Sweden.—Sweden produced ferrochromium and stainless steel. Vargön Alloys AB (58°21'29.83" N, 12°22'54.04" E), Vargön, Västra Götalands Län, a Yildrim Group (Turkey) company, produced ferrochromium. Vargon operated with ferrochromium production capacity of about 230,000 t/yr from four furnaces (SBB Daily Briefing, 2009b). Outokumpu (Finland) produced stainless steel at its Avesta plant in Avesta, Dalarnas Län (Outokumpu Ojy, 2010).

Turkey.—Turkey produced chromite ore, chromium chemicals, and ferrochromium. Eti Krom A.S., a Yildirim Group company, produced chromite ore and high-carbon ferrochromium (38°39'10" N, 39°46'10" E). Eti Krom's ferrochromium production capacity was 150,000 t/yr (Eti Krom Inc., undated). Eti Elektrometalurji A.S. produced chromite ore and high- and low-carbon ferrochromium near Antalya (36°56'08" N, 30°39' E) from an annual production capacity of 12,000 t/yr low-carbon ferrochromium and 12,000 t/yr high-carbon ferrochromium (Eti Elektrometalurji A.Ş., undated).

United Kingdom.—The United Kingdom produced chromium metal and stainless steel. Outokumpu (Finland) produced stainless steel at its Sheffield plant (Outokumpu Ojy, 2008, p. 33). London & Scandinavian Metallurgical Co. Ltd. (53°24'57" N, 1°22' W) produced chromium metal by aluminothermic reduction at Rotherham, United Kingdom (London & Scandinavian Metallurgical Co Limited, undated). Elementis plc, a leading world chromium chemicals producer, manufactured sodium dichromate from chromite ore at Castle Haynes (North Carolina, United States) and Eaglescliffe (Stockton-on-Tees, United Kingdom). Elementis closed the Eaglescliffe plant (54°31'30" N, 1°22'50" W) in July (Elementis plc, 2010, p. 7, 9).

Zimbabwe.—Zimbabwe produced chromite ore and ferrochromium. Chromex Mining plc (United Kingdom) purchased Falvect Mining (Private) Limited, a company that owns chromite concessions in the Shurugwe and Ngezi areas (Chromex Mining plc, 2010).

Zimbabwe Alloys reprocessed chromite ore dumps, improved chromium recovery in the furnace, and recovered chromium from slag. Mining and smelting started in 1953 when fines were not suitable furnace feed and metal was not recovered from slag. As a result, the operation stockpiled these materials (Chirasha and Shoko, 2010). Use of briquetted recovered chromite ore fines resulted in improvement in production, power specific consumption, chromium recovery, and chrome ore specific consumption.

Current Research and Technology

Mineral Processing and Industrial Applications.—South Africa's Council for Mineral Technology (Mintek) continued conducting Government- and commercial-sponsored research and development on chromite ore and ferrochromium. Mintek developed mine-specific processes for chromite ore beneficiation, developed platinum recovery process applied to chromite ore tailings, developed furnace controller technology for ferrochromium-producing furnaces, and developed stainless steel dust recycling technology. Mintek expected the first commercial use of an electrode monitor that reports the position of the electrode tip in a ferrochromium-producing electric arc furnace (Mintek, 2009, p. 43). Mintek recovered platinum from chromite ore tailings using its ConRoast process, which involves roasting followed by direct current arc smelting (Mintek, 2010, p. 23).

A concise international chemical assessment on inorganic chromium (III) compounds was published by the International Programme on Chemical Safety—a cooperative program of the World Health Organization, the International Labour Organization, and the United Nations Environment Programme (Santonen and others, 2009). Natural and anthropogenic sources, routes of exposure, and concentrations at which environmental or human impact could be expected were discussed.

Holappa (2010) reported energy (3,100 to 3,500 kilowatthours of electricity per metric ton of high-carbon ferrochromium produced from a closed submerge-arc furnace) and raw materials consumption data and the CO_2 emission factor for ferrochromium production (about 1.6 t of CO_2 per metric ton of ferrochromium). Reduction in CO_2 emissions by more energy-efficient production, higher recovery rates, and other ways were also discussed. A bioaccessibility study of ferrochromium, ferrochromium silicon, and a common grade of stainless steel found that very little chromium was released (less than 0.15% expressed as amount of metal released per amount of particles loaded) from ferrochromium and even less from ferrochromium silicon or stainless steel (Midlander and others, 2010).

Outlook

The outlook for chromium consumption in the United States and the rest of the world is about the same as that for stainless steel, which is the major end use for chromium worldwide. In 2009, China and India were in the process of economic expansion that resulted in increasing need for chromium to produce stainless steel; however, chromium consumption did not recover to 2008 peak levels.

The practice of supplying chromium in the form of ferrochromium by countries that mine chromite ore was interrupted as China became a major producer of ferrochromium; however, that trend was not expected to continue as China closed small, inefficient, environmentally unfriendly ferroalloy production facilities. The rising cost of ferrochromium sustained independent ferrochromium producers; however, other factors being equal, ferrochromium production is most cost effective when the ferrochromium plant is close to the chromite mine. With new efficient and reliable ferrochromium production facilities in chromite ore-producing countries, ferrochromium production capacity and production are expected to diminish in market-driven economies that produce ferrochromium without nearby chromite ore resources. Other factors of production, such as electrical energy or labor costs, can offset chromite ore transportation costs. Further vertical integration of the chromium industry is expected as countries that produce chromite ore expand ferrochromium or stainless steel production capacity.

Chromite Ore.—Chromite ore production capacity was expected to remain in balance with average consumption. To improve chromite ore availability and to stabilize feed material prices, ferrochromium producers invested in mines that produce chromite ore. Indeed, most chromite ore was produced under vertically integrated mine-smelter or mine-plant ownership. As platinum mining moves to chromite-bearing seams in South Africa, a greater portion of chromite is likely to be supplied as byproduct from such operations. In addition, platinum may become a byproduct of some chromite operations when efficient recovery of platinum from chromite tailings is developed.

Chromium Chemicals.—Leading chromium chemical-producing countries where large sodium dichromate plants (production capacity in excess of 100,000 t/yr) operate included Kazakhstan, Russia, and the United States. Moderate-sized production facilities were located in China, India, Japan, South Africa, Turkey, and the United Kingdom. Small-scale local producers operated in China and India.

Ferrochromium.—Ferrochromium production is electrical energy intensive. Charge-grade ferrochromium requires 2,900 to 4,100 kilowatthours of electrical energy per metric ton of product, with efficiency varying by ore grade, operating conditions, and production process. Thus, ferrochromium plant location will reflect a cost balance between raw materials and electrical energy supply.

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TABLE 1
SALIENT CHROMIUM STATISTICS[1]

		2005	2006	2007	2008	2009
World, production, contained chromium:						
Chromite ore (mine)[2]	metric tons	5,920,000 r	6,080,000 r	7,040,000 r	7,410,000 r	5,940,000
Ferrochromium (smelter)[3]	do.	3,930,000 r	4,190,000	4,770,000 r	4,590,000 r	3,990,000
Stainless steel[4]	do.	4,130,000	4,820,000	4,730,000	4,410,000 r	4,180,000
U.S. supply:						
Components of U.S. supply, contained chromium:						
Domestic mines	do.	--	--	--	--	--
Secondary[5]	do.	174,000	179,000	162,000	146,000	141,000
Imports:						
Chromite ore[2]	do.	52,900	53,800	46,400	64,300	23,000
Chromium chemicals	do.	11,400	12,100	10,600	18,000	10,600
Chromium ferroalloys	do.	278,000	265,000	259,000	307,000	140,000
Chromium metal	do.	11,000	10,900	11,700	13,100	7,570
Stainless steel mill products and scrap	do.	150,000	179,000	158,000	157,000	91,800
Stocks, January 1:						
Government	do.	466,000	375,000	253,000 [6]	115,000	155,000 [7]
Industry[8]	do.	7,900	8,520 r	9,620 r	9,940 r	7,290
Total	do.	1,150,000	1,080,000	910,000	831,000	576,000
Distribution of U.S. supply, contained chromium:						
Exports:						
Chromite ore[2]	do.	13,700	17,400	12,000	2,280	743
Chromium chemicals	do.	18,900	16,700	21,000	22,600	13,500
Chromium ferroalloys and metal	do.	24,700	22,300	27,000	11,300	2,900
Stainless steel mill products and scrap	do.	162,000	156,000	231,000	250,000	263,000
Stocks, December 31:						
Government	do.	375,000	272,000 [6]	115,000	105,000 [9]	129,000
Industry[8]	do.	8,520 r	9,620 r	9,940 r	7,290 r	7,050
Total	do.	603,000	493,000 r	416,000	399,000	416,000
Production, reported, chromium ferroalloy and metal net production[10]		W	W	W	W	W
Consumption:						
Apparent, contained chromium	do.	548,000	589,000 r	493,000	432,000	160,000
Reported:						
Chromite ore and concentrates, gross weight	do.	W	W	W	W	W
Chromium ferroalloys:[11]						
Gross weight	do.	424,000 r	422,000 r	462,000 r	427,000 r	394,000
Contained chromium	do.	247,000 r	249,000 r	272,000 r	251,000 r	231,000
Chromium metal, gross weight	do.	7,270	6,160	5,410	4,740 r	4,240
Stocks, December 31, gross weight:						
Government:[6]						
Chromite ore	do.	73,400	1,160	--	--	--
Chromium ferroalloys	do.	492,000	373,000	155,000	140,000 [9]	175,000
Chromium metal	do.	6,190	5,280	4,970	4,820	4,670
Industry:						
Producer[12]	do.	W	W	W	W	W
Consumer:						
Chromium ferroalloys[13]	do.	13,800 r	15,500 r	16,300 r	11,700 r	11,400
Chromium metal	do.	229	220	221	235 r	160
Other	do.	304	231	216	271	263
Prices, average annual:						
Chromite ore[14]	dollars per metric ton	NA	119	244	348	158
Ferrochromium, chromium content[15]	dollars per pound	0.684	0.695	1.048	1.748	0.806

See footnotes at end of table.

TABLE 1—Continued
SALIENT CHROMIUM STATISTICS[1]

		2005	2006	2007	2008	2009
Prices, average annual—Continued:						
Electrolytic chromium metal, gross weight[16]	do.	4.50	4.50	NA	NA	NA
Aluminothermic chromium metal, gross weight[17]	do.	2.72	2.94	3.66	5.30	4.08
Value of trade:[18]						
Exports	thousands	$116,000	$121,000	$150,000	$149,000	$86,600
Imports	do.	$583,000	$529,000	$699,000	$1,430,000	$444,000
Net exports[19]	do.	-$468,000	-$408,000	-$548,000	-$1,280,000	-$358,000
Stainless Steel:						
Production:						
Gross weight[20]	metric tons	2,240,000	2,460,000	2,170,000	1,930,000	1,620,000
Contained chromium[21]	do.	373,000	419,000	360,000	324,000 [r]	276,000
Average grade, dimensionless[22]		0.1667	0.1705	0.1656	0.1684	0.1703
Shipments, gross weight[23]	metric tons	1,730,000	1,890,000	1,700,000	1,380,000	1,200,000
Exports, gross weight	do.	371,000	410,000	476,000	471,000	414,000
Imports, gross weight	do.	770,000	872,000	809,000	783,000	416,000
Scrap, gross weight:						
Receipts	do.	1,030,000	1,050,000	953,000	858,000	832,000
Consumption	do.	1,480,000	1,500,000	1,430,000	1,330,000	1,260,000
Exports	do.	585,000	506,000	882,000	1,000,000	1,130,000
Imports	do.	111,000	180,000	118,000	140,000	124,000
Value of trade:						
Exports	thousands	$1,340,000	$1,580,000	$2,110,000	$2,300,000	$1,450,000
Imports	do.	$2,630,000	$3,210,000	$4,300,000	$4,040,000	$1,710,000
Scrap exports	do.	$670,000	$716,000	$1,620,000	$1,190,000	$777,000
Scrap imports	do.	$124,000	$209,000	$198,000	$217,000	$138,000
Net exports[19, 24]	do.	-$744,000	-$1,130,000	-$770,000	-$773,000	$384,000

[r] Revised. do. Ditto. NA Not available. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Calculated assuming chromite ore to average 44% Cr_2O_3, which is 68.42% chromium.

[3] Calculated assuming chromium content of ferrochromium to average 57% chromium.

[4] Calculated from American Iron and Steel Institute reported stainless steel production assuming chromium content of stainless steel to average 16.7% chromium.

[5] Calculated assuming chromium content of stainless steel to average 17% chromium.

[6] "Summary of Commodities" as reported by the Defense National Stockpile Center (DNSC) through 2006. "Inventory of Stockpile Material" as reported by DNSC starting in 2007 except where noted otherwise.

[7] From January 1, 2009 to December 31, 2009, the DNSC made an accounting adjustment to low-carbon ferrochromium stocks making them (the stocks for those months) incompatible for the purpose of computing stock change for that year. January stocks were estimated.

[8] Includes consumer stocks of chromium ferroalloys and metal and other chromium-containing materials.

[9] From January 1, 2008 to December 31, 2008, the DNSC changed its high-carbon and low-carbon ferrochromium stocks accounting method making them (the stocks for those months) incompatible for the purpose of computing stock change for that year. December stocks were estimated based on monthly stock changes excluding the accounting-change month.

[10] Includes chromium ferroalloys and metal and other chromium materials in the United States.

[11] Chromium ferroalloy, chromite ore, and other chromium-containing materials excluding chromium metal.

[12] Chromium ferroalloy and metal producer stocks of chromium ferroalloys and metal.

[13] Consumer stocks of high- and low-carbon ferrochromium and ferrochromium-silicon.

[14] Time-weighted average price of South African chromite ore that contains 44% Cr_2O_3 f.o.b. South Africa as reported in Ryan's Notes.

[15] Time-weighted average U.S. price of imported high-carbon chromium that contains 50% to 55% chromium as reported in Platts Metals Week.

[16] Time-weighted average U.S. price of domestically produced electrolytic chromium metal as reported by Ryan's Notes.

[17] Time-weighted average U.S. price of imported aluminothermic chromium metal as reported by Ryan's Notes.

[18] Includes chromite ore and chromium ferroalloys, metal, and chemicals.

[19] Negative data indicate that imports are greater than exports.

[20] Source: American Iron and Steel Institute annual report of stainless and heat-resisting raw steel production and shipments.

[21] Estimated mass-weighted average of the mean chromium content of stainless steel production by grade. Uncertainty is approximately ± 0.01, owing to the range of chromium chemical specification limits by stainless steel grade.

[22] Ratio of estimated mass-weighted average chromium content of stainless steel production by grade to production. Expressed as a fraction.

[23] Source: American Iron and Steel Institute annual report of stainless and heat-resisting raw steel shipments.

TABLE 1—Continued
SALIENT CHROMIUM STATISTICS[1]

[24] Includes stainless steel and stainless steel scrap.

Source: American Iron and Steel Institute quarterly reports of stainless and heat-resisting raw steel production by grade.

TABLE 2
U.S. REPORTED CONSUMPTION AND STOCKS OF CHROMIUM PRODUCTS[1]

(Metric tons)

	2008		2009		Change[2]	
	Gross weight	Chromium content	Gross weight	Chromium content	Quantity	Percentage
Consumption by end use:						
Alloy uses:						
Steel:						
Carbon steel	6,200	3,740	5,760	3,500	-432	-7
High-strength low-alloy steel	3,690	2,490	5,810	2,330	2,110	57
Stainless and heat-resisting steel	345,000	199,000	323,000	188,000	-21,100	-6
Full alloy steel	23,600	14,400	13,400	8,200	-10,200	-43
Unspecified steel[3]	27,600	17,200	26,900	16,000	-651	-2
Superalloys	9,670 r	7,530 r	8,740	6,920	-929	-10
Other alloys and uses[4]	16,100 r	10,800 r	14,300	9,660	-1,820	-11
Total	431,000 r	256,000 r	398,000	235,000	-33,000	-8
Consumption by material:						
Low-carbon ferrochromium	43,800 r	30,000 r	38,700	25,600	-5,070	-12
High-carbon ferrochromium	353,000	209,000	323,000	192,000	-29,900	-8
Ferrochromium silicon	W	W	W	W	W	W
Chromium metal	4,740 r	4,670 r	4,240	4,210	-502	-11
Chromium ore	1,150	375	5,070	1,660	3,920	340
Chromium-aluminum alloy	454	293	355	219	-98	-22
Other chromium materials	28,000 r	11,000 r	26,600	11,200	1,340	5
Total	431,000 r	256,000 r	398,000	235,000	-33,000	-8
Consumer stocks:						
Low-carbon ferrochromium	1,960 r	1,340	2,040	1,350	81	4
High-carbon ferrochromium	8,770	5,190	8,560	5,080	-203	-2
Ferrochromium silicon	964 r	379 r	764	321	-200	-21
Chromium metal	235 r	231 r	160	159	-75	-32
Chromium-aluminum alloy	126	82	119	73	-7	-6
Other chromium materials	146	61	144	62	2	1
Total	12,200 r	7,290 r	11,800	7,050	-405	-3
National Defense Stockpile stocks:[6]						
Chromium ferroalloys:[7]						
High-carbon ferrochromium	139,000 r	99,200 r	113,000	80,800	-25,800	-19
Low-carbon ferrochromium	70,900 r	50,600 r	61,500	48,900	-9,410	-13
Chromium metal[8]	4,820	4,820	4,670	4,670	-152	-3

[r] Revised. W Withheld to avoid disclosing company proprietary data; included in "Other chromium materials."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Change based on gross weight quantity of unrounded data of current year compared with that of previous year.

[3] Includes electrical, tool, and unspecified steel end uses.

[4] Includes cast irons, welding and alloy hard-facing rods and materials, wear- and corrosion-resistant alloys, and aluminum, copper, magnetic, nickel, and other alloys.

[5] The source for stockpile information is the Defense Logistics Agency, Defense National Stockpile Center (DNSC).

[6] The DNSC data is based on the "Total Uncommitted Inventory" of stockpile material D-1 report.

[7] Chromium content estimated using 71.4% chromium.

[8] Chromium content estimated using 100% chromium.

TABLE 3

VALUE OF IMPORTS AND U.S. PRICE QUOTATIONS FOR CHROMIUM MATERIALS[1]

Material		2008		2009	
		Contained chromium	Gross weight	Contained chromium	Gross weight
Value:[2, 3]					
Chromite ore:					
Not more than 40% chromic oxide	dollars per metric ton	XX	XX	2,030	344
More than 40% but less than 46% chromic oxide	do.	788	247	1,980	621
46% or more chromic oxide	do.	675	222	641	203
Average	do.	696	227	762	227
Ferrochromium:					
Not more than 0.5% carbon	do.	7,520	5,130	4,490	3,040
More than 0.5% but not more than 3% carbon	do.	4,880	3,160	3,360	2,030
More than 3% but not more than 4% carbon	do.	2,290	1,360	1,000	540
Average (not more than 4%)	do.	7,340	4,990	4,230	2,800
More than 4% carbon	do.	3,370	1,940	1,540	844
Average (all grades)	do.	3,730	2,180	2,090	1,190
Chromium metal[4]	do.	XX	11,100	XX	9,900
Price:[5]					
Chromite ore:[6]					
Turkey[7]					
40% to 42% Cr_2O_3	do.	XX	492	XX	229
44% Cr_2O_3	do.	1,750	526	814	245
South Africa					
39% Cr_2O_3	do.	1,240	330	573	153
44% Cr_2O_3	do.	1,160	348	525	158
High-carbon ferrochromium:[8]					
50% to 55% chromium	cents per pound	174.80	XX	80.57	XX
60% to 65% chromium	do.	205.34	XX	82.45	XX
Low-carbon ferrochromium:[8]					
0.05% carbon	do.	466	XX	236	XX
0.10% carbon	do.	435	XX	210	XX
0.15% carbon	do.	432	XX	209	XX
Chromium metal:					
Imported, aluminothermic[6]	do.	XX	530	XX	408

do. Ditto. XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Mass-weighted average based on customs value and weight of imported material.

[3] Reported by the U.S. Census Bureau.

[4] Average over all grades.

[5] Time-weighted average based on prices reported by material in trade journals.

[6] Source: Ryan's Notes.

[7] Price is cost and freight China.

[8] Source: Platts Metals Week.

TABLE 4

U.S. EXPORTS OF CHROMIUM MATERIALS, BY TYPE[1]

HTS[2] code	Type	2008 Quantity (kilograms)	2008 Value (thousands)	2009 Quantity (kilograms)	2009 Value (thousands)	Principal destinations in 2009 (Quantity in metric tons, value in thousands)
2610.00.0000	Chromite ore and concentrate, gross weight	7,000,000	$4,370	2,500,000	$1,610	Canada (1,550, $851); Mexico (671, $447).
	Metal and alloys, gross weight:					
8112.21.0000	Unwrought chromium powders	389,000	7,030	213,000	4,570	Japan (82, $1,360); Germany (25, $886); Canada (21, $367); Mexico (16, $186); China (15, $410); Brazil (13, $287).
8112.22.0000	Chromium metal waste and scrap	67,900	1,410	19,600	481	Japan (10, $271); Germany (8, $194); Republic of Korea (1, $15).
8112.29.0000	Chromium metal other than unwrought powders and waste and scrap	541,000	12,000	179,000	8,250	Japan (43, $2,610); Hong Kong (33, $1,160); Brazil (18, $675); China (14, $439); Belgium (10, $713); Canada (9, $90); United Kingdom (9, $239); Mexico (7, $256).
	Total chromium metal	998,000	20,400	411,000	13,300	
	Chromium ferroalloys:					
7202.41.0000	High-carbon ferrochromium:[3]					
	Gross weight	10,800,000	14,500	3,200,000	4,270	Canada (1,690, $2,100); Mexico (840, $1,220); Brazil (145, $266).
	Contained weight	4,280,000	XX	1,770,000	XX	
7202.49.0000	Low-carbon ferrochromium:[4]					
	Gross weight	13,400,000	27,500	1,560,000	2,440	Canada (635, $1,050); Japan (436, $587); Mexico (205, $333); Sweden (108, $146); United Kingdom (87, $117); Brazil (53, $104); China (34, $83).
	Contained weight	5,990,000	XX	710,000	XX	
7202.50.0000	Ferrochromium-silicon:					
	Gross weight	216,000	1,140	18,500	109	Hong Kong (all).
	Contained weight	18,200	XX	6,490	XX	
	Total chromium ferroalloys:					
	Gross weight	24,500,000	43,100	4,780,000	6,820	
	Contained weight	10,300,000	XX	2,490,000	XX	
	Chemicals, gross weight:					
	Chromium oxides:					
2819.10.0000	Chromium trioxide	17,400,000	24,700	10,100,000	18,600	China (1,820, $3,950); Brazil (1,720, $2,270); India (962, $1,540); United Kingdom (921, $1,770); Chile (507, $792); Belgium (443, $684); France (398, $563); Indonesia (371, $542); Republic of Korea (302, $598); Canada (255, $878); Mexico (255, $800); Turkey (252, $402).
2819.90.0000	Other	3,610,000	14,100	1,900,000	9,300	Canada (526, $2,230); Spain (351, $800); Belgium (198, $461); Chile (109, $235); Brazil (91, $466); France (69, $1,070); United Kingdom (69, $210); Mexico (68, $333); Germany (60, $863).
	Total chromium oxides	21,000,000	38,900	12,000,000	27,900	
2833.29.4000	Chromium sulfates	52,400	362	16,100	114	Mexico (8, $41); Hong Kong (4, $17); Guatemala (3, $14); India (1, $43).

See footnotes at end of table.

TABLE 4—Continued
U.S. EXPORTS OF CHROMIUM MATERIALS, BY TYPE[1]

HTS[2] code	Type	2008 Quantity (kilograms)	2008 Value (thousands)	2009 Quantity (kilograms)	2009 Value (thousands)	Principal destinations in 2009 (Quantity in metric tons, value in thousands)
	Salts of oxometallic or peroxometallic acids:					
2841.90.4500	Zinc and lead chromate	17,100	$157	56,200	$293	Mexico (18, $54); Colombia (18, $41); Trinidad and Tobago (11, $62); Jamaica (5, $28); Dominican Republic (3, $24); South Africa (1, $68); Taiwan (1, $16).
2841.30.0000	Sodium dichromate	31,300,000	26,000	19,700,000	20,200	Japan (14,800, $14,100); Canada (2,080, $3,240).
2841.50.1000	Potassium dichromate	77,000	338	52,700	276	Hong Kong (26, $206); Canada (25, $62); Taiwan (1, $8).
2841.50.9100	Other	1,380,000	4,650	615,000	2,330	Indonesia (94, $167); Republic of Korea (90, $311); China (88, $377); Canada (76, $267); Vietnam (58, $294); Hong Kong (38, $160); Thailand (27, $97); India (27, $43).
	Total salts	32,800,000	31,200	20,500,000	23,100	
3206.20.0000	Pigments and preparations, gross weight	1,230,000	10,600	1,220,000	13,800	Japan (583, $7,352); Mexico (181, $1,959); Canada (146, $775); Colombia (46, $525); Republic of Korea (34, $233).

XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States of America.

[3] More than 4% carbon.

[4] Not more than 4% carbon.

Source: U.S. Census Bureau.

TABLE 5

U.S. IMPORTS FOR CONSUMPTION OF FERROCHROMIUM, BY COUNTRY[1]

Country	Not more than 0.5% carbon (HTS[2] code 7202.49.5090)			More than 0.5% carbon, but not more than 3% carbon (HTS[2] code 7202.49.5010)			More than 3% carbon, but not more than 4% carbon (HTS[2] code 7202.49.1000)			More than 4% carbon (HTS[2] code 7202.41.0000)			Total all grades		
	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)
2008:															
Brazil	37	25	$116	--	--	--	--	--	--	2,000	1,040	$3,820	2,030	1,070	$3,940
China	4,550	2,920	23,000	340	212	$1,200	--	--	--	632	400	1,730	5,520	3,530	25,900
Germany	5,200	3,580	29,400	--	--	--	--	--	--	--	--	--	5,200	3,580	29,400
India	--	--	--	--	--	--	--	--	--	58,000	35,800	105,000	58,000	35,800	105,000
Italy	--	--	--	--	--	--	--	--	--	159	100	260	159	100	260
Japan	4,220	2,750	15,100	--	--	--	--	--	--	--	--	--	4,220	2,750	15,100
Kazakhstan	2,130	1,460	6,880	--	--	--	--	--	--	114,000	79,300	310,000	117,000	80,700	317,000
Mexico	--	--	--	--	--	--	--	--	--	38	28	123	38	28	123
Russia	20,100	14,100	113,000	1,490	1,010	5,220	344	204	$466	40,500	26,200	89,900	62,500	41,500	209,000
South Africa	408	249	769	420	227	666	--	--	--	220,000	107,000	310,000	220,000	108,000	312,000
Sweden	359	243	1,550	--	--	--	--	--	--	718	448	1,370	1,080	691	2,910
Zimbabwe	--	--	--	--	--	--	--	--	--	33,200	19,400	87,200	33,200	19,400	87,200
Total	37,000	25,300	190,000	2,250	1,450	7,090	344	204	466	469,000	270,000	910,000	509,000	297,000	1,110,000
2009:															
Albania	--	--	--	--	--	--	--	--	--	558	360	714	558	360	714
Austria	--	--	--	--	--	--	--	--	--	466	301	576	466	301	576
Belgium	--	--	--	--	--	--	17	12	27	--	--	--	17	12	27
China	1,850	1,180	4,730	160	98	368	--	--	--	40	32	142	2,050	1,300	5,240
Germany	3,800	2,640	15,700	--	--	--	--	--	--	--	--	--	3,800	2,640	15,700
India	--	--	--	--	--	--	--	--	--	2,050	1,230	1,870	2,050	1,230	1,870
Japan	1,090	752	4,810	--	--	--	--	--	--	--	--	--	1,090	752	4,810
Kazakhstan	2,030	1,400	6,100	495	348	1,580	--	--	--	43,100	29,500	51,200	45,600	31,300	58,900
Netherlands	22	16	92	--	--	--	--	--	--	--	--	--	22	16	92
Russia	23,900	16,400	71,100	249	175	708	3,160	1,700	1,690	15,900	10,100	15,900	43,200	28,400	89,400
South Africa	3,630	2,160	7,840	1,210	657	1,640	--	--	--	136,000	67,000	96,100	141,000	69,800	106,000
Sweden	115	75	574	--	--	--	--	--	--	317	210	791	433	285	1,370
Turkey	180	126	390	--	--	--	--	--	--	--	--	--	180	126	390
Total	36,600	24,800	111,000	2,110	1,280	4,290	3,180	1,720	1,720	198,000	109,000	167,000	240,000	137,000	285,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States of America.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF CHROMIUM MATERIALS, BY TYPE[1]

HTS[2] code	Type	2008 Quantity (kilograms)	2008 Value[3] (thousands)	2009 Quantity (kilograms)	2009 Value[3] (thousands)	Sources in 2009 (Quantity in metric tons, value in thousands)
	Chromite ore:					
2610.00.0020	Not more than 40% Cr_2O_3:					
	Gross weight	--	--	10,300,000	$3,540	South Africa (all).
	Cr_2O_3 content	--	XX	2,560,000	XX	
2610.00.0040	More than 40%, but less than 46% Cr_2O_3:					
	Gross weight	38,400,000	$9,470	859,000	533	South Africa (all).
	Cr_2O_3 content	17,600,000	XX	394,000	XX	
2610.00.0060	46% or more Cr_2O_3:					
	Gross weight	159,000,000	35,300	66,100,000	13,400	South Africa (all).
	Cr_2O_3 content	76,400,000	XX	30,600,000	XX	
	Total chromite ore:					
	Gross weight	197,000,000	44,800	77,200,000	17,500	
	Cr_2O_3 content	94,000,000	XX	33,600,000	XX	
	Chromium ferroalloys:					
7202.49.5090	Not more than 0.5% carbon:					
	Gross weight	37,000,000	190,000	36,600,000	111,000	Russia (23,900, $71,100); Germany (3,800, $15,700); South Africa (3,630, $7,840); Kazakhstan (2,030, $6,100); China (1,850, $4,730); Japan (1,090, $4,810); Turkey (180, $390); Sweden (115, $574); Netherlands (22, $92).
	Cr content	25,300,000	XX	24,800,000	XX	
7202.49.5010	More than 0.5%, but less than 3% carbon:					
	Gross weight	2,250,000	7,090	2,110,000	4,290	South Africa (1,210, $1,640); Kazakhstan (495, $1,580); Russia (249, $708); China (160, $368).
	Cr content	1,450,000	XX	1,280,000	XX	
7202.49.1000	More than 3%, but less than 4% carbon:					
	Gross weight	344,000	466	3,180,000	1,720	Russia (3,160, $1,690); Belgium (17, $27).
	Cr content	204,000	XX	1,720,000	XX	
7202.41.0000	More than 4% carbon:					
	Gross weight	469,000,000	910,000	198,000,000	167,000	South Africa (136,000, $96,100); Kazakhstan (43,100, $51,200); Russia (15,900, $15,900); India (2,050, $1,870); Albania (558, $714); Austria (466, $576); Sweden (317, $791); China (40, $142).
	Cr content	270,000,000	XX	109,000,000	XX	
7202.50.0000	Ferrochromium-silicon:					
	Gross weight	24,200,000	57,900	7,560,000	9,140	Kazakhstan (all).
	Cr content	9,810,000	XX	3,120,000	XX	
	Total chromium ferroalloys:					
	Gross weight	533,000,000	1,170,000	248,000,000	294,000	
	Cr content	307,000,000	XX	140,000,000	XX	

See footnotes at end of table.

TABLE 6—Continued
U.S. IMPORTS FOR CONSUMPTION OF CHROMIUM MATERIALS, BY TYPE[1]

HTS[2] code	Type	2008 Quantity (kilograms)	2008 Value[3] (thousands)	2009 Quantity (kilograms)	2009 Value[3] (thousands)	Sources in 2009 (Quantity in metric tons, value in thousands)
	Chromium metal, gross weight:					
8112.21.1000	Unwrought chromium powders	1,050,000	$11,700	635,000	$6,410	Russia (360, $2,540); China (156, $2,020); United Kingdom (96, $1,640); France (18, $54); Germany (4, $126); Japan (1, $14).
8112.22.0000	Waste and scrap	523,000	3,000	107,000	797	Mexico (87, $333); Singapore (15, $393); Taiwan (2, $32); United Kingdom (1, $18); Germany (1, $17); Japan (1, $4).
8112.29.0000	Other than waste and scrap	11,500,000	131,000	6,830,000	67,700	United Kingdom (2,930, $30,200); France (1,520, $17,100); China (1,080, $10,200); Russia (979, $8,140); Kazakhstan (230, $784); Germany (42, $896); Italy (38, $144); Netherlands (7, $39); Japan (5, $182).
	Total chromium metal	13,100,000	145,000	7,570,000	74,900	
	Chemicals, gross weight:					
	Chromium oxides and hydroxides:					
2819.10.0000	Chromium trioxide	8,890,000	22,500	6,240,000	18,400	Turkey (3,820, $11,400); Kazakhstan (1,670, $3,940); China (293, $1,480); South Africa (227, $615); Canada (151, $678); Colombia (37, $124); Germany (20, $138); Italy (16, $68); France (2, $6);
2819.90.0000	Other	2,550,000	9,850	2,850,000	9,560	Canada (1,250, $1,460); China (817, $3,810); United Kingdom (400, $1,840); Germany (205, $1,480); Colombia (49, $313); Kazakhstan (39, $165); France (38, $160); Russia (18, $74); Spain (17, $109); Taiwan (12, $108); Finland (7, $38).
	Total oxides	11,400,000	32,300	9,100,000	28,000	
2833.29.4000	Sulfates of chromium	56,400	92	70,600	88	Turkey (39, $48); India (32, $29).
	Salts of oxometallic or peroxometallic acids:					
2841.90.4500	Chromates of lead and zinc	298,000	1,310	32,200	101	Republic of Korea (20, $47); Japan (8, $30); France (4, $25).
2841.30.0000	Sodium dichromate	33,000,000	28,600	15,000,000	17,300	United Kingdom (14,900, $16,900); China (84, $156); Colombia (42, $187); Russia (20, $29).
	Other chromates and dichromates; Peroxochromates:					
2841.50.1000	Potassium dichromate	4,810	29	3,200	10	Mexico (3, $3); Japan (1, $7).
2841.50.9100	Other	320,000	905	239,000	711	Austria (111, $325); Colombia (48, $110); Canada (30, $88); France (21, $89); Germany (20, $51); China (8, $23); Taiwan (1, $22).
	Total salts	33,600,000	30,800	15,300,000	18,100	
2849.90.2000	Chromium carbide	129,000	2,460	165,000	3,060	Japan (49, $638); United Kingdom (37, $446); Canada (26, $530); Austria (23, $1,030); Germany (15, $142); China (14, $265).

See footnotes at end of table.

TABLE 6—Continued

U.S. IMPORTS FOR CONSUMPTION OF CHROMIUM MATERIALS, BY TYPE[1]

HTS[2] code	Type	2008 Quantity (kilograms)	2008 Value[3] (thousands)	2009 Quantity (kilograms)	2009 Value[3] (thousands)	Sources in 2009 (Quantity in metric tons, value in thousands)
	Pigments and preparations based on chromium, gross weight:					
3206.20.0010	Chrome yellow	1,120,000	$5,590	1,000,000	$4,670	Canada (536, $3,140); China (222, $599); Mexico (133, $475); Republic of Korea (64, $223); Germany (22, $139); Colombia (19, $65); Brazil (7, $7); Netherlands (1, $18).
3206.20.0020	Molybdenum orange	373,000	3,110	269,000	2,170	Canada (227, $1,960); Mexico (25, $134); Colombia (12, $64); Netherlands (4, $13); Japan (1, $5).
3206.20.0030	Zinc yellow	71,500	192	168,000	464	China (158, $425); Mexico (9, $39).
3206.20.0050	Other	531,000	1,830	254,000	1,350	France (150, $603); Poland (38, $206); China (25, $67); Germany (15, $130); India (11, $73); United Kingdom (7, $169); Brazil (3, $50); Japan (2, $18); Colombia (2, $7); Canada (1, $15); Taiwan (1, $8).
	Total pigments	2,100,000	10,700	1,700,000	8,650	

XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States of America.

[3] Customs import value generally represents a value in the foreign country and therefore excludes U.S. import duties, freight, insurance, and other charges incurred in bringing the merchandise into the United States.

TABLE 7
WORLD PRODUCTION CAPACITY OF CHROMITE ORE, FERROCHROMIUM, CHROMIUM METAL, CHROMIUM CHEMICALS, AND STAINLESS STEEL, AND APPARENT CONSUMPTION IN 2009 and 2006[1]

(Thousand metric tons of contained chromium)

Country	Production capacity					Apparent (consumption[2])	
	Ore	Ferrochromium	Metal	Chemicals	Stainless steel	2009	2006
Afghanistan	2	--	--	--	--	--	--
Albania	77	22	--	--	--	8	22 r
Argentina	--	--	--	13	--	9	20 r
Australia	78	--	--	--	--	-33	-43 r
Austria	--	--	--	--	11	52	102 r
Belgium	--	--	--	--	259	93	174 r
Brazil	205	125	--	--	95	203	164 r
Canada	--	--	--	--	--	9	20 r
China	60	853	6	70	1,700	3,140	1,520 r
Czech Republic	--	--	--	--	3	7	11 r
Finland	185	134	--	--	222	52	158 r
France	--	--	7	--	90	36	83 r
Germany	--	18	1	--	292	160	255 r
Greece	1	--	--	--	--	(3)	(3)
India	1,200	451	(3)	31	302	713	468 r
Indonesia	--	--	--	--	--	-2	-2 r
Iran	77	5	--	2	--	(3)	(3)
Italy	--	--	--	--	292	159	252 r
Japan	1	8	1	17	695	257	500 r
Kazakhstan	1,110	720	2	37	--	169	202 r
Korea, Republic of	--	--	--	--	387	205	222 r
Kosovo	1	--	--	--	--	(3)	--
Madagascar	42	--	--	--	--	15	24 r
Oman	258	--	--	--	--	(3)	-2 r
Pakistan	97	--	--	3	--	-8	-1 r
Philippines	11	--	--	--	--	(3)	-6 r
Poland	--	--	--	--	1	7	11 r
Russia	291	372	16	31	19	241	376 r
Slovakia	--	1	--	--	--	(3)	3 r
Slovenia	--	--	--	--	15	7	14 r
South Africa	2,920	1,900	--	23	117	-532	216 r
Spain	--	--	--	--	214	60	128 r
Sudan	10	--	--	--	--	--	(3)
Sweden	--	86	--	--	116	47	94 r
Taiwan	--	--	--	--	279	201	268 r
Turkey	568	48	--	17	--	64	29 r
Ukraine	--	--	--	--	21	--	(3)
United Arab Emirates	10	--	--	--	--	-1	(3)
United Kingdom	--	--	7	--	64	24	56 r
United States	--	--	3	38	419	150	233 r
Vietnam	31	--	--	--	--	--	--
Zimbabwe	247	135	--	--	--	26	75 r
Total	7,480	4,880	43	282	5,610	XX	XX

r Revised. XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Apparent consumption is chromite ore production plus chromite ore, ferrochromium, and chromium metal net imports. Net imports are imports minus exports. Based on data reported by the International Chromium Development Association. A negative apparent consumption indicates that exports are greater than production plus imports.

[3] Less than ½ unit.

TABLE 8
CHROMITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country[3]	2005	2006	2007	2008	2009
Afghanistan[4]	6,818 [r]	7,273 [r]	6,491 [r]	6,491 [r]	6,000 [e]
Albania[5]	182,772 [r]	212,581 [r]	199,771 [r]	207,104 [r]	256,000 [e]
Australia	241,865	258,087	253,400	224,809	119,314
Brazil[6]	616,534	562,739	627,772	705,726 [r]	700,000 [e]
Burma[4]	410	--	--	--	--
China[e]	200,000	200,000	200,000	200,000	200,000
Cuba	34,000	27,900	25,000	25,000 [e]	25,000 [e]
Finland	571,103	548,713	556,100	613,543	246,817
Greece[4]	1,500	1,500	1,400	1,400 [e]	1,400 [e]
India	3,255,162	3,600,400	3,320,000	3,900,000	3,760,000 [e]
Iran	223,563	244,603	185,760	188,000	255,129
Kazakhstan	3,581,242	3,366,078	3,687,200	3,629,000	3,333,197
Madagascar	140,847	132,335	122,260	84,000	60,000 [e]
Oman	50,400	70,500	407,822	859,748 [r]	636,482
Pakistan	148,432	199,000	323,100	320,000 [e]	275,000 [e]
Philippines	38,081	46,728	31,592	15,268	14,000 [e]
Russia	772,000	966,065	776,681	913,000 [r]	416,194
South Africa	7,552,000	7,418,326	9,646,958	9,682,640	6,865,540
Sudan	21,654	28,772	15,476	31,890	19,000 [e]
Turkey	688,377	1,059,901	1,678,932	1,885,712	1,770,029
United Arab Emirates	--	--	19,000	34,350	23,770
Vietnam	78,915	73,037	103,830	55,880	37,105
Zimbabwe	819,903	712,908	663,593	484,482	279,360
Total	19,200,000	19,700,000	22,900,000 [r]	24,100,000 [r]	19,300,000

[e] Estimated. [r] Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 20, 2010.

[3] Figures for all countries represent marketable output unless otherwise noted.

[4] Gross weight estimated assuming an average grade of 44% chromic oxide (Cr_2O_3).

[5] Ore grade was 18% to 42% Cr_2O_3.

[6] Average chromic oxide (Cr_2O_3) content was as follows: 2005—41.0% (revised); 2006—40.6%; 2007—40.3%; 2008—42.5% (revised); and 2009—40.0%.

TABLE 9
FERROCHROMIUM: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country	2005	2006	2007	2008	2009
Albania	34,400	17,040	--	11,916	7,556
Brazil[3]	197,653	166,577	195,890	194,323 [r]	194,500 [p]
China[e]	850,000	1,000,000	1,300,000	1,500,000 [r]	1,550,000
Finland	234,881	243,350	241,760	233,550	123,310
Germany	22,672	26,710	22,030	26,960	13,667
India[e, 4]	611,373 [5]	634,200 [5]	820,000	750,000	670,000
Iran[e]	8,000	7,000	8,000	8,000	8,000
Japan[3]	12,367	13,056	12,016	13,888	7,700 [e]
Kazakhstan	1,156,168	1,200,000	1,307,536	1,220,315	1,100,000 [e]
Russia[e]	578,000 [5]	600,000	570,000	490,000	378,000 [5]
Slovakia	867	19	--	--	--
South Africa[6]	2,812,000	3,030,000	3,552,000 [r]	3,269,000 [r]	2,800,000 [e]
Sweden	127,451	136,374	124,403	117,053	31,345
Turkey	26,043	67,975	69,730	75,840 [r]	41,028
United States[7]	W	W	W	W	W
Zimbabwe[e]	218,143 [r, 5]	200,673 [r, 5]	150,000	150,000	73,600
Total	6,890,000 [r]	7,340,000	8,370,000 [r]	8,060,000 [r]	7,000,000

[e] Estimated. [p] Preliminary. [r] Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 20, 2010.

[3] Includes high- and low-carbon ferrochromium.

[4] Includes ferrochrome and charge chrome.

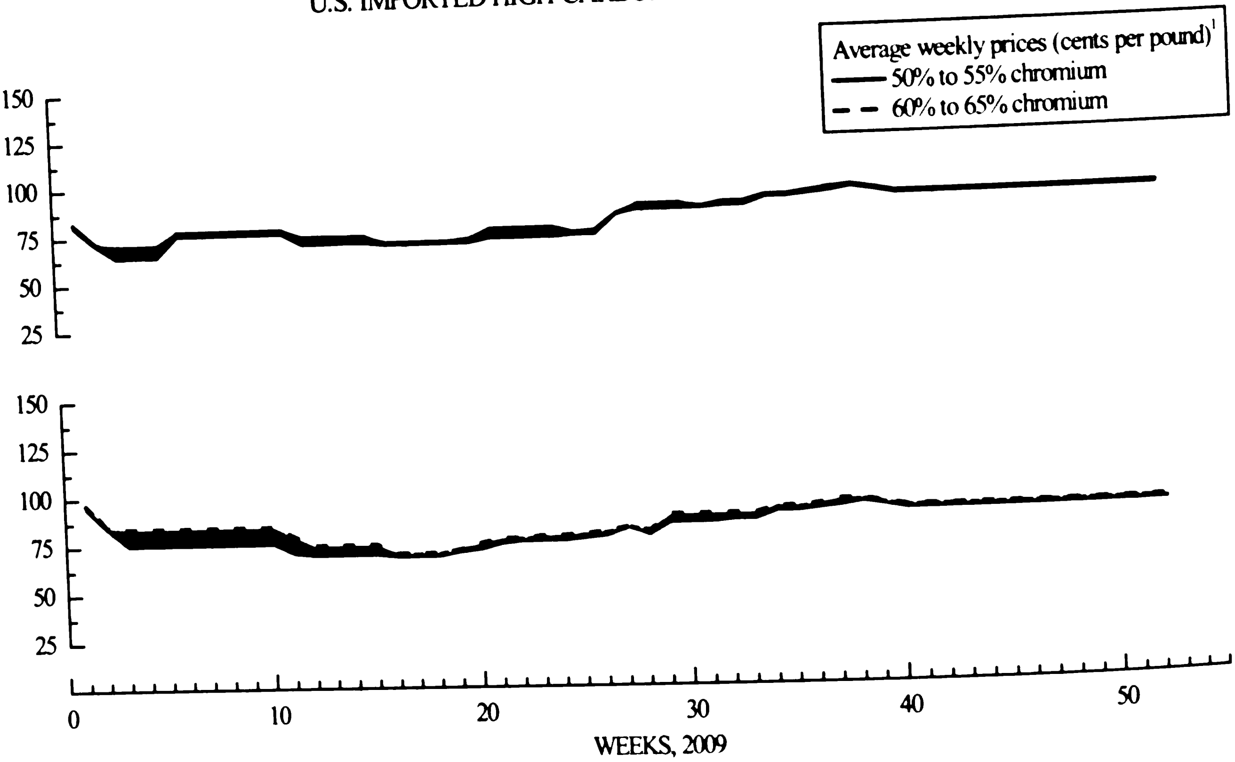
[5] Reported figure.

[6] Includes high- and low-carbon ferrochromium and ferrochromium-silicon.

[7] Includes chromium metal, high- and low-carbon ferrochromium, ferrochromium-silicon, and other chromium materials.

FIGURE 1

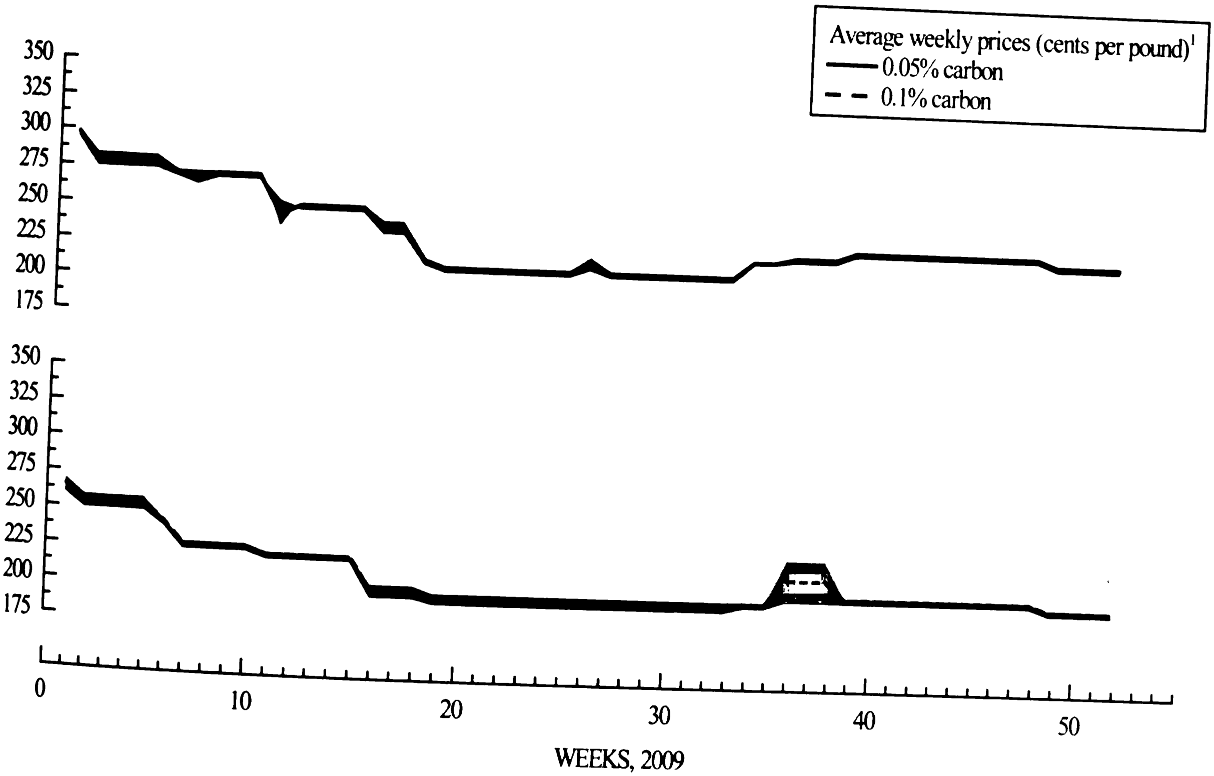
U.S. IMPORTED HIGH-CARBON FERROCHROMIUM IN 2009



[1] Average weekly price shown against price range background.

Source: Platts Metals Week

FIGURE 2
U.S. IMPORTED LOW-CARBON FERROCHROMIUM IN 2009



[1] Average weekly price shown against price range background.

Source: Platts Metals Week

CLAY AND SHALE

By Robert L. Virta

Domestic survey data and tables were prepared by Maria Arguelles, statistical assistant and the world production tables were prepared by Lisa D. Miller, international data coordinator.

The amount of clay sold or used by domestic producers in 2009 declined 25% to 24.5 million metric tons (Mt) valued at $1.33 billion compared with 32.7 Mt valued at $1.65 billion in 2008 (table 1). Common clay and shale accounted for 51% of the tonnage, and kaolin accounted for 54% of the value (tables 1, 5, and 8). In 2009, exports declined 25% to 3.83 Mt valued at $702 million compared with 5.1 Mt valued at $938 million in 2008. Imports of clays were 325,000 metric tons (t) valued at $104 million in 2009 compared with 237,000 t valued at $86.6 million in 2008 (table 1).

About 170 companies mined clay and shale in the United States in 2009. The 20 leading companies, many with multiple operations, accounted for 57% of the tonnage and 81% of the value for all types of clay produced and sold or used. Clay production was reported in all States except Alaska, Delaware, Hawaii, Idaho, New Hampshire, Rhode Island, Vermont, and Wisconsin (table 2). Companies that mined clay for construction fill and landfill caps and did not operate mills or plants were not included in the U.S. Geological Survey (USGS) canvass of the clay and shale industry. These companies operated in most, if not all, States.

The 10 leading producer States were, in decreasing order of tonnage, Georgia, Wyoming, Texas, Alabama, Missouri, North Carolina, Ohio, Virginia, Tennessee, and Mississippi. The 10 leading producer companies were, in alphabetical order, American Colloid Co. (bentonite); BASF SE (bentonite, fuller's earth, and kaolin); Black Hills Bentonite Co. (bentonite); General Shale Products Corp. (common clay and shale); Imerys SA (ball clay and kaolin); KaMin LLC (kaolin); Nestle S.A. (fuller's earth); Oil-Dri Corp. of America. (fuller's earth); Texas Industries Inc. (common clay and shale); and Thiele Kaolin Co. (kaolin).

Most clay mining in the United States was by open pit methods; less than 1% of U.S. clay output was from underground mines. Most underground production was in Ohio, where the clays were mainly underclays associated with coal.

Domestic production data for clays were developed by the USGS from a voluntary survey of U.S. operations. Responses to the survey and company production data available from other sources accounted for approximately 55% of the total clay and shale tonnage sold or used quantity listed in table 1. Most nonrespondents were producers of common clay and shale. Production data for the nonrespondents were estimated from preliminary survey data or reported prior-year production levels adjusted by trends in the industry, employment hours, and other guidelines.

Ball Clay

Production.—In 2009, four companies mined ball clay in four States. Production of domestic ball clay declined 14% to 831,000 t valued at $37.7 million in 2009 compared with 967,000 valued at $44.3 million in 2008 (table 3). Operations in Tennessee supplied 61% of the production, followed by, in descending order of tonnage, Texas, Mississippi, and Kentucky. One producer reported a small amount of production in Indiana, but this probably was fire clay rather than ball clay.

Consumption.—The principal domestic ball clay markets were, in decreasing order by tonnage, floor and wall tile and sanitaryware. Ball clay also was sold to manufacture bricks, fiberglass, refractory products, and other types of ceramics and as fillers, extenders, and binders (table 3). Sales for fiberglass and some filler and extender applications were likely to have been kaolin mined or purchased by the ball clay producers.

Ball clay sales declined largely because the decrease in residential and commercial construction in the United States resulted in a reduced demand for ceramic tile and sanitaryware. Based on data from the U.S. Census Bureau (2010a), production and shipments of clay floor and wall tile were 9% and 10%, respectively, less than in 2008. Production was 55.4 million square meters in 2009 compared with 61 million square meters in 2008 and shipments were 53 million square meters in 2009 compared with 58.9 million square meters in 2008.

Domestic sales of ball clay can be affected by imports of products such as ceramic and sanitaryware because they compete with ball clay-based ceramic products manufactured in the United States. The U.S. International Trade Commission (undated) reported that imports of ceramic tile under Harmonized Tariff Schedule (HTS) of the United States Codes 6907.10.00, 6908.10.10, 6908.10.20, and 6908.10.50 decreased in quantity to 6.95 million square meters valued at $68.6 million in 2009 from 10.8 million square meters valued at $108 million in 2008. Mexico, China, and Italy were the three leading sources of tile imports, with 28%, 22%, and 18% of the import volume, respectively. Imports of sanitaryware under the 4-digit HTS Code 6910 decreased to 21.8 million units in 2009 from 28.7 million units in 2008. China accounted for 10.5 million units or 48% of the U.S. sanitaryware imports in 2009, while Mexico accounted for 7.81 million units or 36% of the imports.

Imerys, the leading ball clay producer in the United States, indicated that it experienced significant sales losses for ceramics as a result of the global economic recession in 2009 (Imerys SA, 2010, p. 17). It is likely that other ball clay producers experienced similar declines in sales.

Prices.—The average value for ball clay reported by domestic producers was $45.37 per metric ton, slightly less than $45.84 per ton in 2008 (table 3). The average value for exported ball clay was $69.62 per ton (table 14).

Trade.—Ball clay exports were 34,900 t valued at $2.43 million in 2009 compared with 64,900 t valued at $4.58 million in 2008, according to the U.S. Census Bureau (table 14). Producers reported exports of 209,000 t (table 3). Most of the difference in exports reported by producers and the U.S. Census Bureau probably involves shipments to Mexico, whose trade statistics suggest that their kaolin import data may have included some imports of ball clay. Also, the water weight of slurry shipments (about 30% to 35% of the shipment weight) also may account for a portion of the extra tonnage reported by producers (table 15).

Outlook.—Most sales of ball clay were for the manufacture of floor and wall tile, sanitaryware, and other construction related ceramics; so the recovery of the housing and commercial construction markets is necessary if the ball clay production is to increase. Although new privately owned housing starts began to increase in 2010, the value of construction put in place continued to decline (U.S. Census Bureau, undated; 2011a). Also, issues remained with mortgage foreclosures and tight credit in the United States. Despite the sluggish economy and low construction activity, the U.S. Census Bureau (2010b) indicated that production and shipments of clay floor and wall tile began to increase.

With global economies gradually recovering from the economic recession, U.S. ball clay sales may increase 8% to 10% in 2010 compared with those of 2009. Even with these anticipated gains, production and sales in 2010 would still be less than those of the past 15 years.

Bentonite

Production.—In 2009, 21 companies produced bentonite in 11 States. About 3.65 Mt valued at $207 million was sold or used in 2009, 26% less than the 4.91 Mt valued at $267 million of bentonite sold or used in 2008 (table 4). Production of nonswelling bentonite decreased 33% to 116,000 t valued at $8.14 million in 2009 from 172,000 t valued at $10.4 million in 2008. Alabama led in the production of nonswelling bentonite, followed by, in descending order of tonnage, Mississippi, Arizona, Colorado, California, and Nevada.

Production of swelling bentonite was 3.53 Mt valued at $198 million in 2009, a decrease of 26% from 4.74 Mt valued at $257 million in 2008. Wyoming led in the production of swelling bentonite, followed by Montana, Utah, Texas, California, Oregon, Nevada, and Mississippi.

Wyo-Ben, Inc. refurbished its bentonite plant in Lucerne, WY. The plant, built in 1980, had been on care-and-maintenance status for about 20 years. The fully automated plant had an annual production capacity of 500,000 metric tons per year (t/yr) and could produce bentonite products for cat litter, drilling mud, foundry sand, and iron ore pelletizing applications (Industrial Minerals, 2009f). The company also submitted a request to the U.S. Bureau of Land Management to mine claims in Hot Springs County, WY (Industrial Minerals, 2009g).

AMCOL International Corp. idled its Belle Fourche, SD, plant in response to declining markets in 2009 but also began investigating new mining sites near Belle Fourche (The Daily Republic, 2009).

Consumption.—In 2009, domestic sales and use of bentonite were 3.00 Mt and total sales (domestic and export) were 3.65 Mt compared with domestic sales of 4.09 Mt and total sales of 4.91 Mt in 2008. Domestic sales of bentonite were 587,000 t for drilling mud (all swelling bentonite), 443,000 t for foundry sand bond (more than 99% was swelling bentonite), 445,000 t for pelletizing iron ore (all swelling bentonite), and 925,000 t for pet waste absorbent (all swelling bentonite). Bentonite also was sold for civil engineering and sealing; fillers, extenders, and binders; waterproofing and sealing; and a variety of other applications (table 4).

These markets are representative of those of swelling bentonite, which accounted for more than 97% of total bentonite sales. The leading use of nonswelling bentonite was in water treatment and filtering. The leading use of nonswelling bentonite was in water treatment and filtering.

For the smaller markets, swelling bentonite accounted for more than 95% of the bentonite sold for adhesives; animal feed; cosmetics, medical, and pharmaceutical; fertilizers; miscellaneous ceramics; miscellaneous chemical manufacturing applications; and paint but less than 30% of the bentonite sold for pesticide carriers and water treatment and filtering.

Sales to nearly all bentonite markets were lower than those of 2008 owing to the global recession.

Prices.—The average value reported by domestic producers for nonswelling bentonite was $70.17 per ton. The average value for swelling bentonite was $56.09 per ton. The average value for all bentonite was $56.71 per ton (table 4). The average value of exported bentonite was $141.04 per ton. The average value of imported bentonite was $307.50 per ton (tables 14, 15).

The price of bentonite that was sold in bulk, crude form in railcars for iron ore pelletizing from the mill in Wyoming was $53 to $61 per ton; foundry-grade that was bagged and shipped in railcars was $77 to $99 per ton; and American Petroleum Institute (API)-grade bentonite that was bagged and shipped in railcars was $77 to $110 per ton. Crushed, dried, loose in bulk bentonite from India was $34 to $38 per ton for pet litter grade. Crude and dried bentonite, sold in bulk, free on board, Milos, Greece, was $72 to $108 per ton for foundry grade (Industrial Minerals, 2009e).

The average annual producer price index (PPI) for bentonite under North American Industry Classification System code 212325C was 155.3 in 2009 (1984=100) compared with 150.2 in 2008. The PPI decreased during the year from 156.0 in January to 154.8 in December. The PPI measured the average change in the selling prices charged by domestic producers of bentonite over time (U.S. Bureau of Labor Statistics, undated).

Trade.—Bentonite exports decreased to 709,000 t valued at $100 million in 2009 from 1.09 Mt valued at $161 million in 2008 (table 14). Canada, Japan, the Netherlands, and Poland accounted for the largest share of the decline in exports. Most of the decline was related to the downturn in demand by the iron ore, foundry, and oil drilling industries. Changes in trade with other countries were relatively minor. Domestic bentonite producers reported exports of 646,000 t (table 4). Much of the discrepancy between data reported by producers and the U.S. Census Bureau data probably resulted from producers including a portion of the exports destined for Canadian and Mexican markets under domestic sales. In addition, some bentonite is packaged domestically and then exported as a finished product, such as cat litter. Sales through U.S. mineral brokers, where producers do not know if the bentonite is used domestically or exported, could also explain part of the discrepancy.

Bentonite imports consisted mainly of untreated bentonite clay and chemically or artificially activated materials. Imports of untreated bentonite were 8,000 t valued at $2.46 million. Imports of artificially activated material were 27,000 t valued at $28.8 million (table 15).

Outlook.—After experiencing a large downturn in early to mid-2009, drilling mud and iron ore pelletizing markets rebounded toward the end of the year because of increased oil drilling and increased demand for steel. Foundry sand bond markets also may improve owing to increased activity in the automotive and heavy industries in 2010. As a result, overall bentonite sales may increase 8% to 10% in 2010. However, growth will not be the same for all markets.

Absorbent markets, particularly pet waste absorbents, were a major, seemingly imperturbable market for swelling bentonite for many years, but sales of bentonite for pet waste absorbents declined as a result of reduced consumer spending (AMCOL International Corp., 2010, p. 29, 33). Pet litter markets may remain unchanged or decline slightly in 2010. Sales of bentonite for oil absorbent applications were expected to increase 7% to 8% in 2010 compared with those of 2009 because the increase in U.S. industrial output in early 2010 compared with 2009 suggested some recovery in the U.S. economy (Federal Reserve, 2011).

AMCOL, a leading producer of bentonite for oil drilling applications, reported a decline in oil drilling in 2009 in response to the global recession and lesser demand for drilling mud (AMCOL International Corp., 2010, p. 29). U.S. drilling activity was less in 2009 than in 2008 (1,310 rotary drilling rigs in 2009 compared with 2,259 drilling rigs in 2008) but began to recover in late 2009 and early 2010. The global rotary drilling rig count was 3,336 in 2008 and 2,304 in 2009 (Baker-Hughes Inc., undated). Sales of bentonite for drilling mud applications may increase 15% to 20% in 2010 compared with those of 2009 because of increased drilling activity in 2010.

Sales of bentonite also were tied to the iron and steel industries because of its use for pelletizing iron ore and as a foundry sand bond (S&B Industrial Minerals S.A., 2010, p. 8). By mid-2009, production of iron ore began to improve and continued into 2010 (Jorgenson, 2011). Sales of bentonite for pelletizing iron ore may increase by 10% to 15% in 2010 based on this information. Sales of bentonite for foundry sand bond applications may increase 5% to 10% in 2010 because of increased U.S. industrial output (Federal Reserve, 2011).

Sales of bentonite for civil engineering applications such as waterproofing and sealing and landfill caps and liners probably will continue to increase gradually as societal needs increase. Other smaller markets for bentonite also may increase 3% to 6% in 2010 as the U.S. economy slowly improves.

Common Clay and Shale

Production.—In 2009, 130 companies produced common clay and shale for manufacturing products in 38 States and Puerto Rico. Companies that mined clay for construction fill and landfill caps and did not operate mills or plants were not included in the USGS canvass of the clay and shale industry. These companies operated in most, if not all, States.

Domestic sales or use of common clay and shale decreased 29% to 12.5 Mt valued at $156 million in 2009 compared with 17.5 Mt valued at $202 million in 2008 (table 5). The 10 leading producing States were, in descending order of tonnage, Texas, Alabama, North Carolina, Ohio, Georgia, New York, Oklahoma, Arkansas, Virginia, and Pennsylvania. These 10 States accounted for 64% of U.S. common clay and shale production. Sales declined in nearly all States owing to decreased residential and commercial building activity in 2009.

Boral Bricks Inc. announced it would reopen a brick plant in Augusta, GA. The company closed the plant earlier in the year because low market demand resulted in a buildup of excess brick inventory at the plant. The company had three plants in Augusta, one of which still remained idle (Emerson, 2009).

Nevada Cement Co. received approval to operate a shale mine near Fernley, NV. The company was to mine shale from the Bureau of Land Management property for use in the production of cement. Mine life was expected to be 25 years with about 100,000 t of shale being extracted (Aggregate Research.com, 2009).

Consumption.—Brick manufacture remained the leading market for common clay and shale, followed by, in descending order of tonnage, lightweight aggregate and portland cement. These three markets accounted for 90% of sales in 2009. Lightweight aggregate sales were subdivided into concrete block (1.31 Mt), structural concrete (731,000 t), miscellaneous lightweight aggregates (597,000 t), and highway surfacing (483,000 t). Other lesser markets included civil engineering, floor and wall tile and other ceramics, heavy-clay (nonbrick) products, and refractory products (table 5). Sales of products made from common clay and shale declined in 2009.

Production of brick was 40% less in 2009 than in 2008 (3.28 billion bricks in 2009 compared with 5.43 billion bricks in 2008), and brick shipments were 31% less (3.59 billion bricks in 2009 compared with 5.19 billion bricks in 2008). Production and shipments of vitrified clay sewer pipe and fittings in 2009 decreased 23% and 41%, respectively, from those of 2008. Production of clay pipe and fitting was 45,000 t in 2009 compared with 58,500 t in 2008, and shipments were 45,500 t in 2009 compared with 77,500 t in 2008 (U.S. Census Bureau, 2010a). These declines are in line with a decrease in housing starts (554,000 units in 2009 compared with 906,000 units in 2008) and value of construction put in place ($908 billion in 2009 compared with $1.07 trillion in 2008) (U.S. Census Bureau, undated; 2011a).

Prices.—The average value for all common clay and shale produced in the United States was $12.48 per ton compared with $11.54 per ton in 2008. The unit value of clay and shale used to produce lightweight aggregate was estimated to be $29.17 per ton in 2009. Average prices for lightweight aggregate produced from clay and shale ranged from $30 to $70 per ton for most applications.

The annual average PPI for common (miscellaneous) clay and shales under North American Industry Classification System code 212325B was 171.7 in 2009 (1984=100) compared with 168.3 in 2008. The PPI increased during the year from 170.5 in January to 172.0 in December. The PPI measured the average change in the selling prices charged by domestic producers of common (miscellaneous) clay and shale over time (U.S. Bureau of Labor Statistics, undated).

Outlook.—Common clay and shale continued to be affected by the U.S. recession in 2009. The industry lost considerable sales because of the sharp decrease in residential and commercial construction in the United States. Sales declined for construction-related products such as brick, drain tile, floor and wall tile, portland cement, roofing granules and tile, and sewer pipe in 2009. The U.S. Census Bureau (2010b) reported the production and shipments of brick, floor and wall tile, and vitrified clay sewer pipe and fitting began to improve in 2010. However, commercial, public, and residential construction did not show signs of improvement in 2010 (U.S. Census Bureau, undated; 2011a). Also, issues remained with mortgage foreclosures and tight credit in the United States. Until these issues are resolved, growth in sales of common clay to those housing-related markets likely will be relatively modest. Even with a sizable increase of up to 8% to 10%, common clay and shale production will remain considerably lower than production levels of the past 30 years.

Fire Clay

Production.—Fire clay producers were mostly refractory product manufacturers that used the clays in firebrick and various heavy-clay products. In 2009, nine firms mined fire clay in six States. Fire clay mined by domestic producers increased 8% to 320,000 t valued at $12.0 million from 296,000 t valued at $11.8 million in 2008 (table 6). Missouri was the leading producing State, followed by, in descending order of tonnage, California, Ohio, Texas, Washington, and Colorado. The 8% increase in production took place primarily because several producers that sell common clay and shale indicated that they also mined fire clay in 2009; most of their fire clay production, however, was used for common clay applications. Sales of fire clay for the manufacture of products used by refractory markets declined because of decreased demand for fire brick.

A.P. Green (a subsidiary of ANH Refractories Co.) reopened its refractory plant in Fulton, MO, in late November in response to increased orders from the cement and steel manufacturing companies. Orders declined in early 2009 because customers were drawing down their inventories of fire brick before reordering (Norfleet, 2009).

Harbison-Walker Refractories Co. (a subsidiary of ANH Refractories Co.) decided to idle its refractory product plant in Fairfield, AL, because of an overall decline in U.S. demand for refractory products in 2009. The plant was expected to reopen when demand increased (Feytis, 2009).

Consumption.—Consumption of fire clay increased 8% to 320,000 t in 2009 from 296,000 t in 2008. Markets for fire clay were, in descending order of tonnage, refractory calcines and grogs, portland cement, floor and wall tile, refractory mortar and cement, firebrick, common brick, miscellaneous ceramics, and pottery (table 6).

Fire clay products sold included grogs and calcines; high-alumina brick and specialties; ramming and gunning mixes; refractory products, such as firebrick and block; mixes and mortars; and saggers. Fire clays also were used to produce such items as brick and pottery. Sales for these nonrefractory products increased because several common clay and shale producers indicated that they also mined fire clay in 2009.

The U.S. Census Bureau (2010b) reported that the value of U.S. manufacturers' shipments of clay refractory products (based primarily on fire clay and kaolin) was $764 million in 2009 compared with $925 million in 2008. The value of U.S. apparent consumption (manufacturers' shipments plus imports minus exports) of all clay refractory products was $368 million in 2009 versus $546 million in 2008. In 2009, shipments of fire clay, high-alumina, and insulating brick shapes in 9-inch equivalents, were 237,000 t, a decline of 43% from those of 2008. Shipments of castables, gunning mixes, and unshaped clay refractory bonding mortars were 374,000 t in 2009, a decline of 27% from those of 2008. Shipments of clay and high alumina refractory materials for reprocessing and direct sales were withheld by the Census Bureau in 2009 to avoid disclosing company proprietary data.

Prices.—In 2009, the average value for fire clay reported by domestic producers was $37.53 per ton, a decrease from $39.86 per ton in 2008 (table 6). The decrease in value in 2009 from that of 2008 resulted from a large decline in sales of higher-value fire clay for the manufacture of refractory products. The average value of exported fire clay was $130.48 per ton. The average value of imported fire clay was $943.26 per ton (tables 14, 15).

Trade.—In 2009, exports decreased to 328,000 t valued at $42.8 million compared with 393,000 t valued at $49.6 million in 2008 (table 14). A decrease in exports to Luxembourg, a major distribution center for European shipments, accounted for the largest share of the U.S. export decline. In general, exports declined because of lower global demand for refractory products. At least 43% of the exports reported by the U.S. Census Bureau under the HTS code for fire clay was thought to be refractory-grade kaolin rather than fire clay based on the locations of ports from which the material was exported. In 2009, imports were 141 t valued at $133,000 (table 15).

Outlook.—After declining in 2009, sales for fire clay may increase 10% to 15% in 2010 compared with that of 2009. The Federal Reserve indicated that industrial output began to increase in 2010 (Federal Reserve, 2011). Consequently, major users of refractory products such as the aluminum, glass, iron, lime, and steel industries may plan to increase their production, possibly resulting in increased demand for refractory products for their furnaces.

RHI AG, a major world producer of refractory products, reported improved sales in the second half of 2009 and anticipated additional growth in 2010 (RHI AG, 2010).

Sales for construction-related products, such as brick, cement, lightweight aggregate, and tile, that are manufactured using fire clay face the same issues as common clay and shale, a dependence on growth in the private housing and commercial construction sections to support growth in heavy-clay markets. These fire clay markets may increase 5% to 7% in 2010 compared with those of 2009.

Fuller's Earth

Production.—In 2009, 13 companies produced fuller's earth in 11 States. Fuller's earth deposits grade from palygorskite (attapulgite) in Florida to montmorillonite, further northward in Georgia. Gellant grades of attapulgite, used as thickeners in such items as drilling muds and paints, were mined in western Florida and southwestern Georgia. Absorbent grades of attapulgite were mined further north in Georgia. Absorbent grades of attapulgite were grouped with the montmorillonite variety of fuller's earth in table 7 to be consistent with past reporting.

Gellant-grade attapulgite was mined or sold in the Florida Panhandle and southwestern Georgia by two companies.

Attapulgite production was withheld to avoid revealing company proprietary data but production decreased in 2009 compared with that of 2008 (table 7). Florida led in the production of attapulgite, followed by Georgia.

Production of the montmorillonite variety of fuller's earth decreased 14% to 2.01 Mt valued at $206 million in 2009 compared with 2.34 Mt valued at $230 million in 2008 (table 7). Montmorillonite-type fuller's earth was produced, in decreasing order of tonnage, in Georgia, Missouri, Mississippi, Virginia, California, Illinois, Florida, Tennessee, Nevada, Kansas, and Texas. Georgia, Missouri, and Mississippi accounted for 61% of U.S. production.

Active Minerals International, LLC, opened a mine and mill in Climax, GA. The partially processed attapulgite from the Climax operation was shipped to a Quincy, FL, facility for additional processing. The mine and mill had a design capacity of 180,000 t/yr (Active Minerals International LLC, undated).

Oil-Dri Corp. of America expanded its Ripley, MS, plant to produce a granular product for agricultural markets, specifically carriers for herbicides, insecticides, and fungicides. The $7 million plant addition had a capacity of 10,000 to 15,000 t/yr. Oil-Dri planned to spend $12 million on additional plant expansions at Ripley (Industrial Minerals, 2009d).

Consumption.—Consumption of fuller's earth (excluding attapulgite-type fuller's earth) was 2.01 Mt in 2009 compared with 2.34 Mt in 2008. Pet waste absorbent was the leading market for fuller's earth, followed by oil and grease absorbents; fillers, extenders, and binders; and clarifying, decolorizing, and filtering of oils and greases (table 7). These markets were representative of those of montmorillonite-type fuller's earth, which accounted for most of the total fuller's earth sales. The leading uses of attapulgite-type fuller's earth were in fillers, extenders, and binders; drilling mud; clarifying, decolorizing, and filtering of oils and greases; and oil and grease absorbents. Montmorillonite grades dominated sales to most fuller's earth markets although attapulgite accounted for most of the sales of fuller's earth for adhesives, cosmetic, medical, and pharmaceutical applications; and drilling mud.

Prices.—The average value of attapulgite-type fuller's earth was withheld to avoid disclosing company proprietary data but the value decreased from that of 2008. The average value of montmorillonite-type fuller's earth was $102.48 per ton, an increase from $98.29 in 2008 (table 7). The average value of exported fuller's earth was $317.02 per ton. The average value of imported fuller's earth was $75.51 per ton (tables 14, 15).

Trade.—In 2009, exports decreased to 89,900 t valued at $28.5 million compared with 127,000 t valued at $44.0 million in 2008 (table 14). Japan accounted for about 61% of the decline in exports. Exports to other countries declined only slightly or remained relatively unchanged. Imports of decolorizing earth and fuller's earth were 1,270 t valued at $95,900 in 2009 (table 15).

Outlook.—Pet waste absorbent is the leading market for fuller's earth. The leading U.S. provider of fuller's earth for pet waste absorbent applications indicated that its retail and wholesale sales increased by 6% through part of 2010 (Oil Dri Corp., 2010b, p. 15). Based on this information, overall sales for pet waste applications may increase 4% to 6% in 2010.

The second leading market for fuller's earth is in oil and grease absorbents. These sales are tied to industrial output where increased heavy manufacturing and machining results in increased use of oil and grease absorbents. In early 2010, industrial output increased slightly (Federal Reserve, 2011). This suggests that 2010 sales of fuller's earth for oil and grease absorbent applications may increase 5% to 7% compared with those of 2009.

According to one major fuller's earth producer, sales as carriers and suspension agents in fertilizers and pesticides used for agriculture and lawn and garden products decreased in 2009 as a result of the economic slowdown. The same was true of sports products for baseball fields and golf courses as municipalities and other purchasers of sport-related products reduced spending (Oil-Dri Corp. of America, 2010a, p. 17). Consequently, only slight growth may take place in 2010 compared with 2009.

Other uses for fuller's earth are relatively small in volume compared to absorbent applications. Sales for clarifying, decolorizing, and filtering of animal, mineral, and vegetable oils and greases are dependent on the quality of the oil source. Consequently, sales tend to vary yearly rather than follow economic trends. However, one major producer of fuller's earth for this application increased sales by the end of 2009 and in early 2010 (Oil-Dri Corp. of America, 2010a, p. 17). Sales of attapulgite-type fuller's earth for construction-related filler and extender applications, such as in adhesives, asphalt emulsions, caulks, joint compounds, paint, and roof coatings, may increase 1% to 3% in 2010. Sales for drilling mud applications may increase 10% to 15% in 2010 compared with those of 2009, assuming the U.S. economy continues to improve and energy demand also increases.

In general, any improvement in the U.S. economy will likely result in slightly improved sales for nonabsorbent applications for fuller's earth. The factors discussed above suggest that overall sales of fuller's earth my increase 7% to 10% in 2010, an improvement compared with that of 2009 but still below the production and sales levels in recent years.

Kaolin

Production.—In 2009, 17 firms mined kaolin in 9 States. Domestic production decreased 22% to 5.29 Mt valued at $714 million compared with 6.74 Mt valued at $900 million in 2008 (table 8). The leading producer State was Georgia, followed by, in descending order of tonnage, South Carolina, Alabama, Arkansas, Nevada, Florida, Texas, North Carolina, and California.

Of the 5.29 Mt sold or used in 2009, 2.33 Mt was reported as water washed, 1.18 Mt was calcined, 894,000 t was airfloat, 824,000 t was delaminated, and 55,300 t was unprocessed (table 8). This compares with 3.08 Mt of water washed, 1.39 Mt of calcined, 1.13 Mt of airfloat, 1.07 Mt of delaminated, and 78,000 t of unprocessed in 2008 (table 8). Pigment-grade (low-temperature calcined kaolin) accounted for more than 50% of the tonnage of the total calcined kaolin sales. Actual sales of pigment-grade calcined kaolin were withheld to avoid revealing company proprietary data. Companies in Georgia accounted for nearly all the pigment-grade calcined kaolin produced in 2009. A small amount also was produced in Texas.

Kaolin production in Georgia decreased 21% to 4.97 Mt valued at $693 million in 2009 compared with 6.29 Mt valued at $872 million in 2008. Approximately 2.28 Mt of Georgia kaolin production sold was reported as water washed, 1.10 Mt was calcined (high- and low-temperature calcined kaolin), 824,000 t was delaminated, and 761,000 t was airfloat in 2009. This compares with 3.00 Mt water washed, 1.36 Mt calcined, 1.07 Mt delaminated, and 859,000 t airfloat in 2008 (table 9). Production in South Carolina declined 28% to 144,000 t valued at $8.59 million in 2009 compared with 199,000 t valued at $11.3 million in 2008 (table 10).

Imerys, one of the leading U.S. kaolin producers, indicated that sales in most markets declined in 2009. Sales to paper applications declined globally with the downturn in demand for printing and writing paper, partially resulting from decreased advertising and inventory reductions by major paper manufacturers. Sales for construction and manufacturing markets, such as adhesives, paint, plastics, and refractory products declined with the downturn in European and North American manufacturing (Imerys, 2010, p. 17, 18, 26, 30). Imerys reduced production capacity at its Sandersville, GA, plant in response to decreased U.S. sales (Imerys, 2010, p. 59).

Applied Minerals, Inc. (formerly Atlas Mining Co.) continued to develop its halloysite mine in Juab County, Utah. The company also signed an agreement to have KaMin LLC process up to 24,000 t of halloysite, with the option to adjust processing steps and increase capacity if indicated by the market (Business Wire, 2009; Industrial Minerals, 2009b).

Advanced Primary Minerals Corp. (APM) opened its kaolin processing plant in Dearing, GA. The plant produced air-float kaolin in its initial stage of operation for ceramic tile and sanitaryware. Tests were planned to determine the feasibility of producing calcined and hydrous kaolin products for catalyst and paint markets. Plant capacity, when fully operational, for air-float kaolin was to be 50,000 t/yr, and anticipated capacity for wet processed kaolin, if it is determined to be economically feasible, was to be 150,000 t/yr. APM processed kaolin mined in McDuffie County, GA (Advanced Primary Minerals Corp., 2009; Industrial Minerals, 2009a).

The U.S. Forest Service approved Daleco Resources Corp.'s plan to mine kaolin in Sierra County, NM. The deposit, located in the Gila National Forest, reportedly contains an estimated 55.3 Mt of recoverable mineralized material (Daleco Resources Corp., 2009, p. 10).

Consumption.—Consumption of kaolin decreased 22% to 5.29 Mt in 2009 from 6.74 Mt in 2008 (table 8). The major domestic markets for kaolin were, in descending order of tonnage, paper coating and filling, refractory products, catalyst manufacture, and fiberglass and mineral wool. Other large markets were paint, rubber, heavy-clay products (brick and portland cement), and ceramics (table 11).

Paper coating and filling markets accounted for 58% of kaolin sales in 2009 but also accounted for 65% of the decline experienced by the industry in 2009. Nearly all major kaolin end-use markets declined in 2009 in response to the global economic recession.

For Georgia producers, the slowdown in paper- and construction-related markets affected their sales. Sales of kaolin produced in Georgia decreased 21% to 4.97 Mt in 2009 compared with 6.29 Mt in 2008. Major domestic markets for kaolin from Georgia were, in descending order by tonnage, paper coating and filling; refractory products; ceramics and glass; and fillers, extenders, and binders (table 9).

South Carolina producers were most affected by a slowdown in sales to rubber and construction markets. Sales by the South Carolina kaolin producers decreased 28% to 144,000 t in 2009 compared with 199,000 t in 2008. Major domestic markets for kaolin from South Carolina were, in descending order of tonnage, catalyst manufacture (under Ceramics), rubber, brick, fiberglass, and plastics (table 10).

Prices.—The average value of kaolin was $134.97 per ton for all kaolin grades. The average value for airfloat was $81.88 per ton; delaminated, $143.20 per ton; unprocessed, $21.64 per ton; and water washed, $136.91 per ton. Values for refractory-grade (high-temperature calcined) and pigment-grade (low-temperature calcined) kaolin were concealed to avoid revealing company proprietary data, but all types of calcined kaolin combined were valued at $172.03 per ton (table 8). The value of pigment-grade kaolin declined slightly in 2009. The average value of exported kaolin was $200.44 per ton. The average value of the imported kaolin was $244.48 per ton (tables 14, 15).

The price of number 1 paper coating grades of kaolin from a plant in Georgia was $161 to $204 per ton and the price of number 2 paper coating grades was $105 to $162 per ton. The price of refractory clay products from Georgia, in bulk bags, was $143 per ton (Industrial Minerals, 2009e).

The annual average PPI for ball clay and kaolin mining under North American Industry Classification System code 2123240 was 176.6 in 2009 (1984=100) compared with 156.5 in 2008. The PPI was relatively constant throughout the year with the largest increase being from 164.3 in December 2008 to 176.4 in January 2009. The PPI measured the average change in the selling prices charged by domestic producers of ball clay and kaolin over time (U.S. Bureau of Labor Statistics, undated).

Trade.—Exports declined in 2009 largely because the global economic downturn resulted in a reduced demand for kaolin for paper manufacture. In 2009, 2.29 Mt of kaolin valued at $459 million was exported compared with 2.96 Mt valued at $606 million in 2008 (table 14). Decreased shipments of kaolin to Canada and Japan accounted for 66% of the decline in U.S. exports. Producers reported exports of 1.52 Mt (table 11). Much of the 445,000 t destined for Canada and 264,000 t for Mexico probably was reported under domestic consumption by U.S. producers. Sales through U.S. mineral brokers, where producers do not know if the kaolin is used domestically or exported, also could explain part of the discrepancy.

Kaolin imports were an estimated 281,000 t of kaolin valued at $68.7 million in 2009 compared with 194,000 t valued at $46.1 million in 2008 (table 15). Inaccuracies have been observed in some of the kaolin import data from Brazil in the past, raising the possibility that imports in 2009 may have been 290,000 t to 300,000 t. If so, there would have been a slight decrease in imports in 2009, which would have been consistent with trends in the paper industry. About 89% of the kaolin was imported from Brazil, followed by Canada and the

United Kingdom. Imports from Brazil were primarily for paper coating applications, and those from the United Kingdom were primarily for paper filler applications.

Outlook.—Sales by the kaolin industry continued to be hampered by a changing paper market. Kaolin faced competition from ground and precipitated calcium carbonate for many years and continues to do so. Additionally, U.S. paper production industry declined for several years. Paper production by the Confederation of European Paper Industries member countries declined an estimated 11% in 2009 (Confederation of European Paper Industries, 2010). However, paper shipments by U.S. manufacturers began to increase in 2010 as did the production of printing and writing paper (American Forest & Paper Association, 2010; U.S. Census Bureau, 2011b). Even a slight increase in paper production in many regions of the globe in 2010 will benefit the U.S. kaolin industry. Sales of kaolin for paper applications may remain unchanged or increase only slightly in the United States in 2010. Export sales of kaolin may increase 6% to 10%, particularly in Asian markets, where economic growth surpassed other parts of the world.

Industrial output for manufacturing improved in early 2010 (Federal Reserve, 2011). This suggested that sales for manufacturing-related applications in industries such as catalysts, chemicals, plastics, refractory products, and rubber may increase 5% to 10% in 2010 compared with 2009.

Commercial, public, and residential construction did not show signs of improvement in 2010 (U.S. Census Bureau, undated; 2011a). Also, issues remained with mortgage foreclosures and tight credit in the United States. Consequently, sales for construction-related applications, such as the manufacture of brick, electrical porcelain, fiberglass, floor and wall tile, paint, portland cement, roofing granules, and sanitaryware may increase only slightly, 1% to 3%, in 2010 compared with those of 2009 if the construction trend continues through 2010.

World Review

World production of bentonite was approximately 9.66 Mt (table 16). Fuller's earth production was 3.21 Mt (table 17). Kaolin production was about 33 Mt (table 18), including ball clay from Australia, Ukraine, and various other countries, and crude kaolin ore production tonnages were reported by many countries. World sales of processed kaolin were estimated to be between 20 and 22 Mt, after excluding 4.1 Mt for Uzbekistan, 2.8 Mt for Germany, 2 Mt for the Czech Republic, 1.4 Mt each for Bulgaria and Ukraine, 500,000 t for Italy, 300,000 t each for Turkey and Vietnam, 200,000 t for Egypt, and 100,000 t each for Australia and Iran, to account for processing losses and stockpiling. The United States continued to be the leading supplier of processed clay for sale, followed by Greece and Turkey for bentonite, Spain for fuller's earth, and Brazil and the United Kingdom for kaolin. Spain led all countries in the production of sepiolite. Senegal was the leading producer of palygorskite (attapulgite), followed by the United States. The rankings above were based on processed clay sold or used and not on crude ore production.

Azerbaijan.—AzRospromInvest (a joint venture between Azerbaijan and Russia) completed construction of its bentonite processing plant near its Dash Salahli bentonite deposit in the Gazakh region. Plant capacity was 250,000 t/yr of activated bentonite (Azeri Times, The, 2009).

Brazil.—Vale S.A. announced that kaolin production at its subsidiary, CADAM S.A., increased in the third quarter of 2009 because of strong demand in Asian markets. Production for its subsidiary, Pará Pigmentos S.A., decreased because of weak demand in other global markets. However, overall kaolin sales for Vale declined to 781,000 t in 2009 compared with 1.13 Mt in 2008 (Vale S.A., 2009, 2010).

India.—Italian bentonite producer, Laviosa, formed a joint venture with Trimex Industries Ltd. to mine bentonite in the State of Gujarat. The joint venture was to build a plant, scheduled to open in early 2010, with a 70,000-t/yr capacity for bentonite and 120,000-t/yr capacity for dried granular products. The joint venture planned to supply bentonite for cat litter, iron ore pelletizing, and drilling mud (Industrial Minerals, 2009c).

Italy.—S&B Industrial Minerals S.A. transferred its shares of Bentec S.p.A. to Laviosa Chimica Mineraria SpA, an Italian bentonite producer that is partially owned by S&B. The $1.53 million share transfer gave Laviosa full ownership of Bentec, allowing the two companies to merge and simplify their organizational structures (S&B Industrial Minerals S.A., 2009).

Venezuela.—RusKaolin (a joint venture between the Venezuelan government and Russian Agapov-owned Kaolin Venezuela) planned to mine kaolin in the State of Bolivar. The deposit contained more than 38 Mt of reserves. Production was planned to be 300,000 t/yr (VHeadline.com, 2009).

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TABLE 1

SALIENT U.S. CLAY STATISTICS[1, 2]

(Thousand metric tons and thousand dollars)

	2005	2006	2007	2008[r]	2009
Domestic clays sold or used by producers:					
Quantity	41,200	41,200	36,700	32,700	24,500
Value	1,590,000	1,770,000	1,750,000	1,650,000	1,330,000
Exports:					
Quantity	5,620	5,980	5,650	5,100	3,830
Value	929,000	1,000,000	928,000	938,000	702,000
Imports for consumption:					
Quantity	301	346	231	237	325
Value	59,400	79,200	73,900	86,600	104,000

[r] Revised.

[1] Excludes Puerto Rico.

TABLE 2
CLAYS SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1, 2]

(Thousand metric tons and thousand dollars)

State[3]	2008		2009	
	Quantity	Value	Quantity	Value
Alabama	1,970	34,400	1,340	25,300
Arkansas	796	10,700	539	7,630
California	618	6,930	340	4,690
Colorado	143	684	61	435
Florida	21	2,520	18	3,000
Georgia	7,880 [r]	929,000 [r]	5,600	697,000
Indiana	667	8,080	413	6,610
Iowa	269	1,140	184	828
Kansas	548	2,840	381	2,430
Kentucky	419	8,170	288	5,980
Louisiana	509	12,900	353	9,120
Michigan	365	1,730	318	1,310
Mississippi	869	6,030	263	1,540
Missouri	496	3,470	421	3,020
New York	745	28,200	605	30,200
North Carolina	1,270	12,900	828	4,980
Ohio	983	15,900	770	13,400
Oklahoma	756	3,900	572	2,800
Pennsylvania	640	4,840	451	3,040
South Carolina	690	13,500	455	9,890
South Dakota	155	W	W	W
Tennessee	723	27,000	624	23,600
Texas	2,140	25,700	1,850	21,600
Utah	479	10,200	342	7,230
Virginia	766	8,540	505	5,830
Wyoming	4,440 [r]	233,000 [r]	3,270	172,000
Other[4]	3,360 [r]	241,000 [r]	3,760	269,000
Total	32,700 [r]	1,650,000 [r]	24,500	1,330,000

[r] Revised. W Withheld to avoid disclosing company proprietary data; included in "Other."

[1] Excludes Puerto Rico.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Publishable totals used to avoid disclosing company proprietary data.

[4] Includes all other producer States, concealed data within States, and data represented by symbol W.

TABLE 3

BALL CLAY SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY TYPE AND USE[1]

(Thousand metric tons and thousand dollars)

	2008		2009	
	Quantity	Value	Quantity	Value
Type:				
Airfloat	690	31,000	588	26,000
Water-slurried	103	4,920	93	4,440
Unprocessed	174	8,380	151	7,230
Total	967	44,300	831	37,700
Use:				
Fillers, extenders, binders[2]	39	NA	37	NA
Floor and wall tile	340	NA	299	NA
Miscellaneous ceramics[3]	92	NA	77	NA
Pottery	12	NA	4	NA
Sanitaryware	202	NA	181	NA
Miscellaneous[4]	28	NA	24	NA
Exports, reported by producers[5]	255	NA	209	NA
Total	967	44,300	831	37,700

NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes animal feed; asphalt emulsions; rubber; and other fillers, extenders, and binders.

[3] Includes catalysts, electrical porcelain, fiberglass, fine china/dinnerware, glass, mineral wool, and roofing granules.

[4] Includes heavy-clay products, waterproofing seals, refractories, and other unknown uses.

[5] Includes ceramics and glass and floor and wall tile.

TABLE 4

BENTONITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY TYPE AND USE[1]

(Thousand metric tons and thousand dollars)

	2008		2009	
	Quantity	Value	Quantity	Value
Type:				
Nonswelling	172	10,400	116	8,140
Swelling	4,740 [r]	257,000 [r]	3,530	198,000
Total	4,910 [r]	267,000 [r]	3,650	207,000
Use:				
Domestic:				
Pet waste absorbents	1,040 [r, e]	NA	925 [e]	NA
Adhesives	31 [r]	NA	9	NA
Animal feed	95	NA	60	NA
Drilling mud	954	NA	587	NA
Filler and extender applications[2]	84	NA	69	NA
Foundry sand	567 [r, e]	NA	443 [e]	NA
Pelletizing (iron ore)	686 [r, e]	NA	445 [e]	NA
Waterproofing and sealing	168	NA	102	NA
Miscellaneous civil engineering	305 [r, e]	NA	190 [e]	NA
Miscellaneous[3]	160 [r]	NA	170	NA
Total	4,090 [r, e]	NA	3,000 [e]	NA
Exports, reported by producers:				
Drilling mud	149 [r, e]	NA	105 [e]	NA
Foundry sand	259	NA	192	NA
Other[4]	410 [r]	NA	349	NA
Total	818 [r, e]	NA	646 [e]	NA
Grand total	4,910 [r]	267,000 [r]	3,650	207,000

[e]Estimated. [r]Revised. NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes asphalt tiles, asphalt emulsions, cosmetics, fertilizers, ink, medical, miscellaneous fillers and extenders applications, paint, paper coating, paper filling, pesticides and related products, pharmaceuticals, and plastics.

[3] Includes ceramics, chemical manufacturing, clarifying and decolorizing, heavy-clay products, oil and grease absorbents, refractories, and other unknown uses.

[4] Includes absorbents, fillers and extenders, refractories, pelletizing, and other unknown uses.

TABLE 5
COMMON CLAY AND SHALE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE AND USE[1, 2]

(Thousand metric tons and thousand dollars)

	2008		2009	
	Quantity	Value	Quantity	Value
State:				
Alabama	1,970	34,400	1,340	25,300
Arkansas	796	10,700	539	7,630
California	469	3,570	318	2,370
Georgia	952	6,020	631	3,870
Indiana	667	8,080	413	6,610
Kansas	548	2,840	381	2,430
Kentucky	419	8,170	288	5,980
Louisiana	509	12,900	353	9,120
Mississippi	433	2,340	263	1,540
Missouri	496	3,470	421	3,020
New York	745	28,200	605	30,200
North Carolina	1,260	12,900	828	4,980
Ohio	983	15,900	770	13,400
Oklahoma	756	3,900	572	2,800
Pennsylvania	640	4,840	451	3,040
South Carolina	461	2,130	311	1,300
Texas	2,070	13,700	1,800	13,000
Utah	479	10,200	342	7,230
Virginia	766	8,540	505	5,830
Other[3]	2,050	9,140	1,330	6,170
Total	17,500	202,000	12,500	156,000
Use:				
Floor and wall tile[4]	241	NA	181	NA
Heavy-clay products:				
Brick, extruded	8,020	NA	5,680	NA
Brick, other	795	NA	547	NA
Other[5]	266	NA	165	NA
Lightweight aggregate:				
Concrete block	1,890	NA	1,310	NA
Highway surfacing	341	NA	483	NA
Structural concrete	897	NA	731	NA
Miscellaneous	810	NA	597	NA
Portland and other cements	2,670 [r]	NA	1,900	NA
Refractories[6]	596	NA	360	NA
Miscellaneous[7]	947 [r]	NA	493	NA
Total	17,500	202,000	12,500	156,000

[r] Revised. NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes Puerto Rico.

[3] Includes all other States except Alaska, Delaware, Hawaii, Idaho, Nevada, New Hampshire, Rhode Island, Vermont, and Wisconsin.

[4] Includes ceramic tile, quarry tile, and miscellaneous floor and wall tiles.

[5] Includes drain tile, flower pots, flue linings, sewer pipe, structural tile, and miscellaneous clay products.

[6] Includes firebrick, blocks and shapes, mortar and cement, grogs and calcines, and miscellaneous refractories.

[7] Includes exports, reported by producers; miscellaneous civil engineering and sealings; miscellaneous fillers, extenders, and binders; pottery; roofing granules; and other unknown uses.

TABLE 6
FIRE CLAY SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

(Thousand metric tons and thousand dollars)

	2008		2009	
	Quantity	Value	Quantity	Value
Production	296 r	11,800 r	320	12,000
Use:				
Heavy-clay products and lightweight aggregates[2]	127 r	NA	146	NA
Refractories:				
Firebrick, block, shapes	W	NA	19	NA
Grogs and calcines	W	NA	W	NA
Other refractories[3]	W	NA	W	NA
Miscellaneous[4]	169	NA	155	NA
Total	296 r	11,800 r	320	12,000

r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes common brick, concrete block, portland cement, and structural concrete.

[3] Includes kiln furniture, mortar and cement, and miscellaneous refractories.

[4] Includes floor tile, wall tile, and other unknown uses.

TABLE 7
FULLER'S EARTH SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY TYPE AND USE[1]

(Thousand metric tons and thousand dollars)

	2008		2009	
	Quantity	Value	Quantity	Value
Type:				
Attapulgite	(2)	(2)	(2)	(2)
Montmorillonite	2,340 r	230,000 r	2,010	206,000
Total	2,340 r	230,000 r	2,010	206,000
Use:				
Absorbents:				
Oil and grease absorbent	316 r	NA	255	NA
Pet waste absorbent	1,160 r	NA	1,220	NA
Animal feed	51 r	NA	63	NA
Fertilizers	W	NA	W	NA
Fillers, extenders, binders[3]	130 r	NA	107	NA
Filtering, clarifying, and decolorizing[4]	80 r	NA	72	NA
Miscellaneous[5]	581 r	NA	261	NA
Exports, reported by producers[6]	22 r	NA	33	NA
Total	2,340 r	230,000 r	2,010	206,000

r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Withheld to avoid disclosing company proprietary data. Primarily gellant-grade fuller's earth. More information can be found in the "Fuller's Earth" portion of the production section of this report.

[3] Includes asphalt emulsions; medical, pharmaceuticals and cosmetics; paints; pesticides and related products; and other unknown uses.

[4] Includes mineral and vegetable oils and greases.

[5] Includes civil engineering, drilling mud, miscellaneous absorbents, and other unknown uses.

[6] Includes oil and grease absorbents, pet waste absorbents, drilling mud, paint, and other unknown uses.

TABLE 8
KAOLIN SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE AND TYPE[1]

(Thousand metric tons and thousand dollars)

	2008		2009	
	Quantity	Value	Quantity	Value
State:				
Georgia	6,290	872,000	4,970	693,000
South Carolina	199	11,300	144	8,590
Other[2]	257	16,800	180	12,700
Total	6,740	900,000	5,290	714,000
Type:				
Airfloat	1,130	79,700	894	73,200
Calcined:[3]	1,390	260,000	1,180	203,000
Delaminated	1,070	144,000	824	118,000
Unprocessed	78	1,530	55	1,190
Water washed	3,080	414,000	2,330	319,000
Total	6,740	900,000	5,290	714,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes Alabama, Arkansas, California, Florida, Nevada, North Carolina, and Texas.

[3] Includes pigment-grade kaolin (low-temperature calcined kaolin) and refractory-grade kaolin (high-temperature calcined kaolin).

TABLE 9
GEORGIA KAOLIN SOLD OR USED BY PRODUCERS, BY TYPE AND USE[1]

(Thousand metric tons and thousand dollars)

Kind	2008		2009	
	Quantity	Value	Quantity	Value
Type:				
Airfloat	859	63,600	761	62,400
Calcined[2]	1,360	251,000	1,100	195,000
Delaminated	1,070	144,000	824	118,000
Water washed	3,000	413,000	2,280	318,000
Total	6,290	872,000	4,970	693,000
Use:				
Domestic:				
Ceramics and glass:				
Catalysts (oil-refining)	W	NA	W	NA
Fiberglass, mineral wool	251	NA	217	NA
Roofing granules	31	NA	34	NA
Other[3]	372 r	NA	296	NA
Fillers, extenders, binders:				
Adhesives	33	NA	17	NA
Paint	237	NA	164	NA
Paper coating	1,880	NA	1,560	NA
Paper filling	250	NA	196	NA
Plastic	81	NA	57	NA
Rubber	124	NA	121	NA
Other[4]	28	NA	38	NA
Heavy-clay products[5]	(6)	NA	(6)	NA
Refractories[7]	(6)	NA	(6)	NA
Undistributed[8]	931	NA	757	NA
Total	4,220	NA	3,460	NA
Exports, reported by producers:				
Paint	70	NA	53	NA
Paper coating[9]	1,760	NA	1,260	NA
Paper filling[9]	110	NA	46	NA
Rubber	46	NA	41	NA
Undistributed[10]	87	NA	105	NA
Total	2,070	NA	1,500	NA
Grand total	6,290	872,000	4,970	693,000

[r] Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes pigment- and refractory-grade calcined kaolin.

[3] Includes catalysts (oil-refining), electrical porcelain, fine china/dinnerware, pottery, miscellaneous ceramics, and sanitaryware.

[4] Includes animal feed; asphalt tile; fertilizers; medical, pharmaceuticals, and cosmetics; pesticides and related products; and miscellaneous fillers, extenders, and binders.

[5] Includes brick (common and face), portland cement, and miscellaneous clay products.

[6] Withheld to avoid disclosing company proprietary data; included in "Domestic: Undistributed."

[7] Includes firebricks, blocks and shapes, grogs and calcines, high-alumina specialties, kiln furniture, and miscellaneous refractories.

[8] Includes absorbents, chemical manufacturing, floor and wall tiles, heavy-clay products, refractory products, waterproofing seals, and other unknown uses.

[9] Some export sales, by producers, may be included under domestic sales.

[10] Includes miscellaneous ceramics and miscellaneous fillers, extenders, and other unknown uses.

TABLE 10

SOUTH CAROLINA KAOLIN SOLD OR USED BY PRODUCERS, BY USE[1]

(Thousand metric tons and thousand dollars)

	2008		2009	
	Quantity	Value	Quantity	Value
Production[2]	199	11,300	144	8,590
Use:				
Ceramics[3]	79	NA	68	NA
Rubber	45	NA	30	NA
Other uses[4]	75	NA	46	NA
Exports, reported by producers[5]	W	NA	W	NA
Total	199	11,300	144	8,590

NA Not available. W Withheld to avoid disclosing company proprietary data; included in "Other uses."

[1] Data are rounded to no more than three significant digits, may not add to totals shown.

[2] Includes airfloat, unprocessed, and calcined kaolin.

[3] Includes catalysts (oil-refining), fiberglass, roofing granules, and sanitaryware.

[4] Includes adhesives, animal feed, brick (common), floor and wall tile, paper coating, plastics, and refractories.

[5] Includes fillers, extenders, and binders.

TABLE 11
KAOLIN SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

(Thousand metric tons)

Use	2008	2009
Domestic:		
Ceramics:		
Catalyst (oil and gas refining)	295	233
Electrical porcelain	W	W
Fine china and dinnerware	12	7
Floor and wall tile	106	82
Pottery	4	W
Roofing granules	31	34
Sanitaryware	25	35
Miscellaneous ceramics	110 r	84
Chemical manufacture	W	W
Fiberglass, mineral wool	262	224
Fillers, extenders, binders:		
Adhesive	35	19
Fertilizer	W	W
Medical, pharmaceutical, cosmetic	W	--
Paint	255	176
Paper coating	1,890	1,570
Paper filling	250	196
Pesticide	W	W
Plastic	88	63
Rubber	169	150
Miscellaneous fillers, extenders, binders	33 r	39
Heavy-clay products:		
Brick, common and face	52	54
Portland cement	64	55
Refractories[2]	804	614
Miscellaneous applications	167 r	137
Total	4,650 r	3,770
Exports, reported by producers:		
Ceramics[3]	W	W
Paint	83	61
Paper coating	1,760	1,260
Paper filling	110	46
Rubber	52	45
Miscellaneous	91	107
Total	2,090	1,520
Grand total	6,740	5,290

r Revised. W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous ceramics and Miscellaneous fillers, extenders, binders." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes firebrick (blocks and shapes), grogs and calcines, and miscellaneous refractories.

[3] Withheld to avoid disclosing company proprietary data; included in "Exports, reported by producers: Miscellaneous."

TABLE 12
COMMON CLAY AND SHALE USED IN LIGHTWEIGHT AGGREGATE PRODUCTION IN THE UNITED STATES BY STATE[1]

(Thousand metric tons and thousand dollars)

State	Concrete block	Structural concrete	Other[2]	Total Quantity	Total Value[e]
2008:					
Alabama	593	42	71	705	21,000
Arkansas	169	56	--	225	8,690
Indiana	57	41	18	116	3,190
Kansas	--	--	55	55	480
Kentucky	66	72	--	138	6,400
Louisiana	192	77	185	454	12,500
Missouri	--	--	133	133	1,160
Nebraska	--	--	(3)	(3)	2
New York	259	305	--	564	24,900
North Carolina	--	--	6	6	48
Ohio	98	54	93	245	10,300
Oklahoma	28	4	--	32	952
Texas	206	165	360 [r]	730	5,200
Utah	127	80	200	407	9,270
Virginia	91	1	31	124	2,750
Total	1,890	897	1,150	3,930	107,000
2009:					
Alabama	356	25	43	424	14,900
Arkansas	130	32	--	162	6,250
Indiana	91	54	72	218	6,000
Kansas	--	--	62	62	541
Kentucky	46	38	--	84	4,660
Louisiana	132	53	129	314	8,820
Missouri	--	--	124	124	1,080
Nebraska	--	--	1	1	3
New York	153	257	--	411	26,200
Ohio	72	40	68	179	7,700
Oklahoma	20	3	--	23	714
Texas	156	168	409	733	5,270
Utah	93	58	149	300	7,050
Virginia	67	1	23	90	2,060
Total	1,310	731	1,080	3,130	91,300

[e] Estimated. [r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes highway surfacing.

[3] Less than ½ unit.

TABLE 13

COMMON CLAY AND SHALE USED IN BUILDING BRICK PRODUCTION IN THE UNITED STATES, BY STATE[1,2]

(Thousand metric tons and thousand dollars)

State	2008		2009	
	Quantity	Value[e]	Quantity	Value[e]
Alabama	782	9,260	571	6,950
Arkansas	257	1,100	147	705
California	164	978	120	734
Colorado	108	467	42	309
Georgia	884	5,690 [r]	581	3,620
Kentucky[3]	273	1,620	200	1,210
Mississippi	433	2,340	263	1,540
North Carolina	1,250	12,800	828	4,980
Ohio	379	3,450	405	4,770
Oklahoma	541	2,460	415	1,720
Pennsylvania	555	3,450	398	2,230
South Carolina	453	2,080 [r]	301	1,250
Tennessee	155	1,090	113	817
Texas	604	4,080	429	2,150
Virginia	502	2,670	312	1,420
Other[4]	1,480	8,660	1,110	6,590
Total	8,820	62,200	6,230	41,000

[e] Estimated. [r] Revised.

[1] Includes extruded and other brick.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Extruded brick only.

[4] Includes all other States except for Alaska, Nevada, New Hampshire, Rhode Island, Vermont, and Wisconsin.

TABLE 14

U.S. EXPORTS OF CLAYS, BY TYPE[1]

(Thousand metric tons and thousand dollars)

Material	2008		2009		
	Quantity	Value	Quantity	Value	Principal destinations in 2009
Ball clay	65	4,580	35	2,430	Mexico, 30%; Venezula, 13%; Costa Rica, 11%; other, 46%.
Bentonite	1,090	161,000	709	100,000	Canada, 45%; Japan, 11%; Saudi Arabia, 8%; China, 6%; other, 30%.
Fire clay	393	49,600	328	42,800	Mexico, 54%; Luxembourg, 22%; Japan, 9%; other, 15%.
Fuller's earth	127	44,000 [r]	90	28,500	Japan, 18%; China, 9%; United Kingdom, 7%; Germany, 5%; other, 61%.
Kaolin	2,960	606,000	2,290	459,000	Japan, 17%; Canada, 13%; Chile, 11%; Finland, 11%; Mexico, 11%; Germany, 7%; Taiwan, 6%; other, 24%.
Clays, n.e.c.	466 [r]	72,700 [r]	374	69,500	Canada, 70%; Mexico, 4%; Republic of Korea, 3%; other, 23%.
Total	5,100 [r]	938,000 [r]	3,830	702,000	

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 15
U.S. IMPORTS FOR CONSUMPTION OF CLAY, BY TYPE[1]

(Thousand metric tons and thousand dollars)

Material	2008 Quantity	2008 Value	2009 Quantity	2009 Value	Principal sources in 2009
China clay or kaolin	194	46,100	281	68,700	Brazil, 93%; Canada, 5%; Other, 2%.
Fire clay	(2) [r]	79 [r]	(2)	133	Canada, 50%; Germany, 48%; Other, 2%.
Decolorizing earths and fuller's earth	1	100	1	96	Japan, 79%; China, 21%.
Bentonite	7	2,670 [r]	8	2,460	Greece, 46%; Mexico, 23%; Canada, 17%; Other, 14%.
Common blue clay and other ball clay	--	--	--	--	
Other clay	5 [r]	3,230	8	3,940	Peru, 41%; Canada, 38%; Mexico, 6%; Germany, 4%; Other, 11%.
Chamotte or Dina's Earth	(2) [r]	42 [r]	(2)	165	Czech Republic, 69%; Sweden, 21%; United Kingdom, 10%.
Artificially activated clay and earth	30 [r]	34,400 [r]	27	28,800	Mexico, 73%; Germany, 17%; Other, 10%.
Total	237 [r]	86,600 [r]	325	104,000	

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau; data adjusted by U.S. Geological Survey.

TABLE 16
BENTONITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Algeria[4]	29,029	27,110	32,600	30,595	31,000
Argentina	247,101	246,165	250,260	256,182 [r]	250,000
Armenia	732	720	1,129	1,100 [e]	1,100
Australia[e, 4]	223,000	220,000	255,000	250,000	240,000
Azerbaijan	40,000 [e]	40,644	50,459	50,000 [e]	50,000
Bolivia[e]	59 [r, 5]	--	--	1,000 [r]	1,000
Bosnia and Herzegovina	24,882	24,645	32,912	30,504 [r]	30,000
Brazil, beneficiated	221,300	235,481	238,746 [r]	238,800	239,000 [p]
Bulgaria	181,000	134,000	99,000	178,000	170,000
Burma	602	904 [6]	971 [r, 6]	1,000 [r, e, 6]	1,000 [6]
Chile	--	--	533	--	--
Commonwealth of Independent States[e, 7]	-- [r]	-- [r]	-- [r]	-- [r]	--
Croatia	17,391	16,410	19,578	19,500 [e]	19,500
Cyprus[e]	150,000	150,000	150,000	150,000	150,000
Czech Republic	216,000	267,000	335,000	174,000 [e]	116,000
Egypt[e]	30,000	30,000	29,800 [r, 5]	32,000 [r, 5]	32,000
Georgia	7,876	4,487	5,000 [e]	5,000 [e]	5,000
Germany	352,374	363,998	384,709	414,336 [r]	350,000
Greece	1,124,795 [r]	1,125,000 [r]	950,000	1,500,000 [r]	844,804 [5]
Guatemala	135,451	20,034	23,569 [r]	62,749 [r]	14,287 [5]
Hungary	9,000	6,600	54,000 [r]	50,000 [r]	50,000
Indonesia[e]	5,000	5,500	5,500	6,000	6,000
Iran[7]	261,888	260,000 [e]	254,084 [r]	240,000 [e]	250,000
Italy	446,000 [e]	470,000	305,905 [r]	281,119 [r]	146,318 [5]
Japan	421,629	425,000	430,000	435,000 [r]	432,000
Kenya[e]	50	60 [r]	70 [r]	70 [r]	70
Macedonia	25,767	32,507	35,234	22,890	9,033 [5]
Mexico	425,630	435,273	613,895	374,933	511,429 [5]

See footnotes at end of table.

TABLE 16—Continued
BENTONITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Morocco	85,400 [e]	80,400	81,000	80,000	80,000
Mozambique	17,318	3,515	9,707 [r]	17,047 [r]	15,000
New Zealand, processed	7,590	3,028	6,154	753	880 [5]
Pakistan	15,671	23,773	24,000	25,000	26,000
Peru	18,500	19,000	21,451	31,557	119,495 [5]
Philippines	1,000	1,000 [e]	1,148	1,422 [r]	1,500
Poland[8]	86,331	93,880	105,943	121,031	120,000
Romania	20,226	21,165	16,911	16,600 [e]	16,600
Serbia	75 [9]	75	75	75	75
Slovakia	97,000 [r]	136,000 [r]	149,000 [r]	145,000 [r]	145,000
South Africa[10]	139,833	32,878	45,778	44,067	40,340 [5]
Spain	105,000 [e]	154,746	155,000 [e]	155,000 [r]	155,000
Turkey[e]	925,000	950,000	930,000	900,000	1,000,000
Turkmenistan[e]	50,000	50,000	50,000	50,000	50,000
Ukraine[e]	300,000	300,000	300,000	300,000	300,000
United States	4,710,000	4,940,000	4,820,000	4,910,000 [r]	3,650,000 [5]
Zimbabwe[10]	500	500	100	100	100
Total	11,200,000 [r]	11,400,000 [r]	11,300,000 [r]	11,600,000 [r]	9,660,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through September 25, 2010.

[3] In addition to the countries listed, Canada and China are thought to produce bentonite, but output is not reported, and available information is inadequate to make reliable estimates of output levels.

[4] Includes bentonitic clays.

[5] Reported figure.

[6] Year beginning March 21 of that stated.

[7] Information is inadequate to formulate reliable estimates for individual countries, except Armenia, Georgia, Turkmenistan, and Ukraine.

[8] Montmorillite type bleaching clay.

[9] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[10] May include other clays.

TABLE 17
FULLER'S EARTH: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Algeria	831	--	--	--	--
Australia, attapulgite[e]	9,800	10,000	10,000	10,000	9,500
Guatemala	--	19	109	-- [r]	-- [4]
Italy[e]	3,000	3,000	3,000	3,000	3,000
Mexico	107,265	102,400	34,175	66,123	108,139 [4]
Morocco, smectite[e]	15,000	15,000	15,000	15,000	15,000
Pakistan[e]	17,001 [4]	18,000	19,000	20,000	21,000
Senegal, attapulgite	127,000	140,000	150,000 [e]	167,000	170,000
South Africa, attapulgite	34,340 [r]	49,225	68,377	69,876	52,102 [4]
Spain:[e]					
Attapulgite	20,000	20,000	20,000	20,000	20,000
Sepiolite	800,000	800,000	800,000 [r]	800,000	800,000

See footnotes at end of table.

TABLE 17—Continued
FULLER'S EARTH: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
United Kingdom[e, 5]	115,000	--	--	--	--
United States[6, 7]	2,730,000	2,540,000	2,600,000	2,340,000 [r]	2,010,000 [4]
Total	3,980,000	3,700,000	3,720,000	3,510,000	3,210,000

[e]Estimated. [r]Revised. -- Zero.

[1]Excludes centrally planned economy countries and former such countries, some of which presumably produce fuller's earth but for which no information is available. Table includes data available through September 25, 2010.

[2]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[3]In addition to the market economy countries listed, France, India, Iran, Japan, and Turkey have reportedly produced fuller's earth in the past and may continue to do so, but output is not reported, and available information is inadequate to make reliable estimates of output levels.

[4]Reported figure.

[5]Salable product.

[6]Sold or used by producers.

[7]Excludes attapulgite.

TABLE 18
KAOLIN: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Algeria	34,386	32,523	106,567	50,788	50,000
Argentina	54,903	49,619	69,354	55,000 [r]	60,000
Australia, includes ball clay[e]	230,000	250,000	250,000	230,000	230,000
Austria, marketable	55,508	51,900	56,690	49,527 [r]	45,000
Bangladesh[e, 4]	8,400	8,500	8,600	8,500 [r]	8,500
Belgium[e]	300,000	300,000	300,000	300,000	300,000
Bosnia and Herzegovina, crude	14,500 [r]	69,643 [r]	188,033 [r]	259,325 [r]	259,000
Brazil, beneficiated	2,410,000	2,455,000	2,480,000 [r]	2,674,000 [r]	2,680,000 [p]
Bulgaria	1,380,000	1,658,000	1,631,000	1,530,000 [r]	1,530,000
Chile	15,183	44,642	87,901	63,526	48,354 [5]
Czech Republic	3,882,000	3,768,000	3,604,000	3,833,000	2,886,000 [5]
Denmark, sales[e]	2,500	2,500	2,500	2,500	2,500
Ecuador	25,078	11,504	18,618	12,000	13,000
Egypt	415,400	416,000 [e]	331,671 [r]	523,327 [r]	550,000
Eritrea	100	100	100	100	100
Ethiopia	3,726	1,641	1,400 [r, e]	1,275 [r]	3,534 [5]
France, marketable[e]	316,000	300,000	307,253 [5]	300,000	300,000
Germany	3,767,662	3,815,173	3,842,514	3,611,851 [r]	3,200,000
Greece	49,912 [r]	50,000 [r]	40,000 [r]	4,360 [r]	-- [5]
Guatemala	4,107	4,395	2,663 [r]	2,803 [r]	1,879 [5]
Hungary, processed	7,000	7,000	3,000	3,000	3,000
India:[e]					
Processed	190,000	200,000	200,000	210,000	210,000
Salable crude	560,000	560,000	570,000	570,000	580,000

See footnotes at end of table.

TABLE 18—Continued
KAOLIN: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Indonesia[e]	15,000	15,000	15,000	15,000	15,000
Iran[e]	311,501 [5]	310,000	350,000	320,000	320,000
Italy, kaolinitic earth	506,597	469,702	635,297 [r]	591,298 [r]	1,069,938 [5]
Japan	10,500	10,500	11,000	11,000 [e]	12,000
Jordan	168,264	112,787	101,000	181,018 [r]	177,470 [5]
Kenya	780	810	910	940	850
Korea, Republic of	2,767,091	2,399,458	688,330 [r]	954,584	960,000
Kyrgyzstan[e]	400,000	400,000	400,000	400,000	400,000
Malaysia	494,511	341,223	587,508	506,462 [r]	463,736 [5]
Mexico	877,147	961,800	86,784	85,091	78,086 [5]
New Zealand	15,750	14,864	14,130	12,761	9,016 [5]
Nigeria[e]	93,000	100,000	100,000	100,000	100,000
Pakistan	37,732	38,000 [e]	39,000	40,000 [e]	40,000
Paraguay[e]	66,600	66,000	66,000	66,000	66,000
Peru	2,700	5,750	7,532	13,215	9,347 [4]
Poland, washed	159,207	199,755	210,373	221,275	220,000
Portugal	164,072	167,792	183,598 [r]	-- [r]	--
Romania	20,266	11,063	7,576	4,000 [e]	1,000
Russia, concentrate[e]	45,000	45,000	45,000	45,000	45,000
Saudi Arabia	1,500	4,000	4,400	4,400	50,000
Serbia:[e]					
Crude	95,000 [6]	110,000	110,000	110,000	110,000
Washed	16,000 [6]	18,000	10,000	10,000	10,000
Slovakia	31,000	58,000	46,000	44,000 [r]	44,000
South Africa	59,356	51,602	50,839	39,505	31,048 [5]
Spain, marketable, crude and washed[7]	456,000 [r]	464,049	450,000 [r]	465,000 [r]	465,000 [p]
Sri Lanka	9,400 [e]	10,914 [r]	11,178 [r]	10,039 [r]	10,000
Thailand, beneficiated	156,853	157,900	159,186 [r]	162,215	160,000
Turkey	908,862 [r]	1,064,107 [r]	914,117 [r]	900,000 [r, e]	800,000
Uganda[e]	31,000	30,000	30,000	30,000	30,000
Ukraine	1,566,000	1,731,000 [r]	2,172,000 [r]	1,775,000 [r]	1,119,000 [5]
United Kingdom, sales[8]	1,911,000	1,800,000	1,800,000 [e]	1,800,000 [e]	1,800,000
United States[9]	7,800,000	7,470,000	7,110,000	6,740,000	5,290,000 [5]
Uzbekistan[e]	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000
Venezuela[e]	10,000	10,000	10,000	10,000	10,000
Vietnam[e]	650,000	650,000	650,000	650,000	650,000
Zambia[e]	200	200	200	200	200
Total	39,100,000 [r]	38,900,000 [r]	36,700,000 [r]	36,100,000 [r]	33,000,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through September 25, 2010.

[3] In addition to the countries listed, China, Morocco, and Suriname may also have produced kaolin, but information is inadequate to make reliable estimates of output levels.

[4] Data for year ending June 30 of that stated.

[5] Reported figure.

[6] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[7] Includes crude and washed kaolin and refractory clays not further described.

[8] Dry weight.

[9] Kaolin sold or used by producers.

COBALT

By Kim B. Shedd

Domestic survey data and tables were prepared by Cheryl J. Crawford, statistical assistant, and the world production tables were prepared by Lisa D. Miller and Glenn J. Wallace, international data coordinators.

In 2009, world production of refined cobalt increased, primarily as a result of increased production from Australia, China, and Congo (Kinshasa). The United States did not mine or refine cobalt in 2009. However, a small number of mining operations produced negligible amounts of byproduct cobalt as intermediate products. Since 1993, sales of excess cobalt from the National Defense Stockpile (NDS) have contributed to U.S. and world supplies.

According to the Cobalt Development Institute (2010a), world apparent consumption of cobalt was approximately 56,000 metric tons (t), about 8% less than that of 2008. Chinese apparent consumption increased, but consumption from other regions decreased. The U.S. spot price for cobalt generally trended upward after reaching a low of less than $12 per pound in February. Salient U.S. and world cobalt statistics for 2009 and the previous 4 years are listed in table 1.

Cobalt is a metal used in numerous diverse commercial, industrial, and military applications, many of which are considered strategic and critical. On a global basis, the leading use of cobalt is in rechargeable battery electrodes. Superalloys, which are used to make parts for gas turbine engines, are another major use for cobalt. Cobalt is also used to make airbags for automobiles; catalysts for the petroleum and chemical industries; cemented carbides (also called hardmetals) and diamond tools; corrosion- and wear-resistant alloys; drying agents for inks, paints, and varnishes; dyes and pigments; ground coats for porcelain enamels; high-speed steels; magnetic recording media; magnets; and steel-belted radial tires.

Legislation and Government Programs

During fiscal year 2009 (October 1, 2008, through September 30, 2009), the Defense National Stockpile Center (DNSC), U.S. Department of Defense, sold 187 t of cobalt metal valued at $6.80 million under a basic ordering agreement (BOA) (table 2). This represented 14% of the 1,360-metric-ton (3-million-pound) maximum allowed for sale under the fiscal year 2009 Annual Materials Plan (AMP). The AMP for fiscal year 2010 (October 1, 2009, through September 30, 2010) reduced the maximum allowable sale of cobalt to 454 t (1 million pounds) (U.S. Department of Defense, 2010, p. 6–7, and 9).

During calendar year 2009, the DNSC sold 169 t of cobalt valued at $6.30 million under the BOA. On December 31, the total uncommitted cobalt inventory held by the DNSC was 293 t of cobalt cathode.

The Department of Defense (DOD) was directed by Congress to review its current policy to dispose of NDS material and determine whether the NDS was properly configured to assure future availability of materials for defense needs in light of current world market conditions. A DOD working group concluded that DNSC's current disposal policy required revision and that the NDS should be reconfigured into a Strategic Material Security Program to encompass the full range of responsibilities required to develop an integrated and comprehensive approach to strategic materials management. The working group supported DNSC's recommendation to temporarily suspend or limit the sale of 13 materials which had no viable substitutes and on which the United States was wholly or substantially import dependent or at a significant risk of supply disruption. Sales of cobalt were curtailed to hold a goal quantity equivalent to 1 year's AMP (U.S. Department of Defense, 2010, p. 1–2).

Production

With the exception of negligible amounts of byproduct cobalt produced from Stillwater Mining Co.'s platinum-group metal (PGM) operation in southeastern Montana, the United States did not mine or refine cobalt in 2009. Cobalt-bearing nickel sulfate produced from Stillwater's mining and refining operations was sold to several companies. Some of southeastern Missouri's lead ores contained minor amounts of cobalt.

In late 2009, Formation Metals Inc. (formerly Formation Capital Corp.) received approval from the U.S. Forest Service to begin construction of its Idaho cobalt project and began to actively pursue financing. Formation planned to develop an underground cobalt-copper-gold mine and mill complex in the Idaho Cobalt Belt in Lemhi County and retrofit its Big Creek hydrometallurgical complex near Kellogg, ID, to refine the concentrates. The refinery was to produce approximately 1,500 metric tons per year (t/yr) of cobalt as high-grade cathode suitable for critical superalloy applications. Formation estimated that construction would take 12 to 14 months (Formation Metals Inc., 2010, p. 3, 6).

Kennecott Minerals Co., a fully owned subsidiary of Rio Tinto (Melbourne, Australia, and London, United Kingdom), continued to work on permitting for its Eagle project in Michigan. The project comprised a small underground nickel-copper mine in the Eagle deposit in the Yellow Dog Plains area northwest of Marquette and a rehabilitated mill in Humboldt Township, which would produce concentrate for export. At the proposed rate of 16,000 t/yr of nickel, an estimated 400 t/yr of cobalt would be produced during a 7-year mine life, based on nickel and cobalt grades in the resource. By early 2010, Kennecott had received all of the State permits needed for the project (Kennecott Eagle Minerals Co., 2010; Rio Tinto, 2010, p. 39, 41).

The Minnesota Department of Natural Resources and the U.S. Army Corps of Engineers prepared a draft environmental impact statement for PolyMet Mining Corp.'s NorthMet project. The project entailed open pit mining of the NorthMet polymetallic deposit in the Duluth Complex of northeastern

Minnesota, refurbishing the crushing and grinding equipment in the company's nearby Erie plant, and adding a new beneficiation circuit and hydrometallurgical plant. The final products of the project would be copper cathode, a nickel-cobalt mixed hydroxide, and a precipitate of PGMs and gold. PolyMet planned to develop the project in stages and sell either a bulk concentrate or separate copper and nickel concentrates during the construction and commissioning of the hydrometallurgical plant (table 8). PolyMet and Swiss trading firm Glencore International AG had a strategic partnership whereby Glencore would invest in Polymet and purchase or market NorthMet's concentrates, intermediate products, and metal (PolyMet Mining Corp., 2009, p. 9, 13, 15–17, 27).

U.S. processors made cobalt chemicals and cobalt metal powders from refined cobalt materials and (or) cobalt-bearing scrap. U.S. Geological Survey (USGS) data on chemical and metal powder production, shipments, and stocks were derived from a monthly voluntary survey of U.S. cobalt processors. Information from this survey was used to prepare the statistics on cobalt consumption and stocks in table 3. The sole producer of cobalt metal powder, Global Tungsten & Powders Corp. of Towanda, PA, produced the cobalt as a byproduct of tungsten recovered from cemented carbide scrap. U.S. production and shipments of cobalt metal powder are withheld to avoid disclosing company proprietary data.

The Hall Chemical Co. was acquired by newly formed CP Chemicals LP (New Castle, DE) from Meridian Group, the investment banking and management consulting firm that had been appointed as receiver when Hall Chemical ceased operations owing to insufficient funds. The Hall Chemical Co. was founded in 1946 and produced cobalt chemicals at its Wickliffe, OH, plant. The new owners planned to restart operations by yearend (Tascarella, 2009).

Carolmet Cobalt Products (a division of n.v. Umicore, s.a.) ceased production at its Maxton plant near Laurinburg, NC. The plant, which began operations in 1980 as a producer of cobalt metal powder, had been producing cobalt salts prior to its closure (Witten, 2009; n.v. Umicore, s.a., 2010, p. 53).

Consumption

U.S. apparent consumption for 2009, as calculated from net imports, consumption from purchased scrap, and changes in Government and industry stocks, was 26% lower than that of 2008 (table 1). The decrease was primarily because net imports in 2009 were significantly lower than those of 2008.

U.S. reported consumption of cobalt in 2009 was 15% lower than that of 2008. Metallurgical industries used 18% less cobalt than they did in 2008; cobalt consumption for chemical uses was 9% lower. Reported consumption was derived by the USGS from voluntary surveys of U.S. operations. Most of the data on cobalt chemical uses were obtained from the cobalt processors survey. A second survey covered a broad range of metal-consuming companies, such as cemented carbide, magnetic alloy, and superalloy producers. For this survey, more than 60 cobalt consumers were canvassed on a monthly or annual basis. Reported consumption and stocks data in tables 1 and 3 contain estimates to account for nonrespondents.

Prices

The annual average U.S. spot price for cathode (minimum of 99.8% cobalt), as reported by Platts Metals Week, was less than one-half that of 2008 (table 1). After reaching a low of $11.50 to $14.00 per pound in late February, the price generally trended upward and was highest in early November at $22.00 to $23.50 per pound.

Trends in Platts' prices for Zambian cobalt (minimum 99.6% cobalt) and Russian cobalt (minimum 99.3% cobalt) were similar to those for U.S. spot cathode. The annual averages of weekly prices for Zambian cobalt and Russian cobalt were each $16.55 per pound, and less than one-half of those in 2008.

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The London Metal Exchange (LME) launch of a cobalt futures contract was delayed until February 2010. Under the proposed contract, cobalt would trade in 1-metric-ton lots (in 100 to 500 kilogram drums) of minimum 99.3% cobalt, and would be delivered by brand, with impurities identified, to warehouses in Baltimore, Rotterdam, and Singapore. The cobalt would be traded by open outcry ring trading, on an electronic trading platform, and by an interoffice telephone market. LME prices could be used by industry as a reference price. By mid-February 2010, cobalt from the following six producers had been approved for delivery against the LME contract: Jiangsu Cobalt Nickel Metal Co. Ltd., Jinchuan Group Ltd., Kasese Cobalt Co. Ltd., Sumitomo Metal Mining Co., Ltd., Vale Inco Ltd., and Votorantim Metais Niquel S/A (London Metal Exchange Ltd., The, 2010).

Foreign Trade

Net import reliance as a percentage of apparent consumption is used to measure the adequacy of current domestic production to meet U.S. demand. Net import reliance was defined as imports minus exports plus adjustments for Government and industry stock changes. Releases from stocks, including shipments from the NDS, were counted as part of import reliance, regardless of whether they were originally imported or produced in the United States. In 2009, net import reliance as a percentage of apparent consumption was 76%. Because there was no measurable U.S. primary cobalt production in 2009, this indicates that 76% of U.S. cobalt supply was from imports and stock releases of primary cobalt and 24% was from domestic or imported scrap.

In 2009, the United States imported 28% less cobalt than it did in 2008 (tables 4, 5). Ten countries supplied more than 90% of U.S. imports. Norway was the leading supplier, followed by China, Russia, Finland, Canada, Belgium, Australia, Japan, Morocco, and the United Kingdom.

The United States imported 387 t, gross weight, of unwrought cobalt alloys valued at $10.3 million. These materials were sourced from nine countries, with Canada supplying the majority (98%). The United States imported 650 t, gross weight, of cobalt waste and scrap valued at $9.1 million. Eight countries supplied 95% of this material—the United Kingdom (32%), Ireland (31%), Japan (11%), France (7%), Germany (6%), India and Tunisia (3% each), and Mexico (2%). The United States also imported 154 t, gross weight, of wrought cobalt and cobalt articles valued at $15.7 million. The leading suppliers of these materials were the United Kingdom (52%), Canada (18%), Germany (16%), and China, France, and Japan (5% each).

U.S. exports of unwrought cobalt and cobalt contained in chemicals decreased by 14% compared with those of 2008. As listed in table 6, the leading destinations for these exports were Ireland, France, Japan, Belgium, Germany, and China. The United States also exported 1,340 t, gross weight, of wrought metal and cobalt articles valued at $78.5 million.

World Review

Cobalt was produced as a byproduct of copper, nickel, and other metals, and as a primary product. Primary cobalt production included Moroccan mine and refinery production, the artisanal mining of the mineral heterogenite in Congo (Kinshasa), and the recovery of cobalt from previously stockpiled intermediate materials [for example, slags in Congo (Kinshasa) and Zambia], which were processed primarily to recover cobalt.

Refinery capacity by country is listed in table 7. Plants that processed refined cobalt, used secondary materials (scrap) as their main source of feed, or produced a cobalt product that required further refining were not included.

The following review by country focuses on operations in production during 2009. Expansions to those operations and greenfield projects that were forecast to begin producing between 2010 and 2014 are listed in table 8.

Australia.—The Yabulu nickel-cobalt refinery in Townsville, Queensland, operated by Queensland Nickel Pty Ltd., produced 1,700 t of refined cobalt as cobalt oxide hydroxide; 6% more than the 1,600 t produced in 2008. Yabulu processed lateritic ore imported from Indonesia, New Caledonia, and the Philippines, and nickel-cobalt mixed hydroxide from BHP Billiton's Ravensthorpe Mine and processing operation in Western Australia. In early 2009, BHP Billiton announced that it planned to suspend operations at Ravensthorpe and stop refining the mixed hydroxide at Yabulu. BHP Billiton subsequently sold the Yabulu refinery to Australian businessman Clive Palmer and the Ravensthorpe operation to First Quantum Minerals Ltd. (BHP Billiton, 2009b; Cobalt Development Institute, 2010a; First Quantum Minerals Ltd., 2010, p. 9).

BHP Billiton's Nickel West operations in Western Australia processed two types of ore— nickel laterite and nickel sulfide. The laterite operation was the Ravensthorpe Mine and enhanced pressure acid leaching plant. The nickel sulfide operations comprised mines; concentrators, which processed ores mined by BHP Billiton and those from other companies; the Kalgoorlie smelter, where nickel matte was produced; and the Kwinana nickel refinery, which produced cobalt in intermediate nickel-cobalt mixed sulfide that was subsequently toll-refined to cobalt cathode in Norway by Xstrata Nickel (a business unit of Xstrata plc). This tolling agreement reportedly expired during the year (Wallop, 2009).

The Murrin Murrin Nickel Cobalt Joint Venture (60% Minara Resources Ltd. and 40% Glencore) produced a record 2,350 t of cobalt as metal powder and briquettes from its nickel-cobalt laterite mining and pressure-acid leaching operation near Leonora, Western Australia, 16% more than the 2,018 t produced in 2008. Minara's demonstration plant for recovering nickel and cobalt by heap-leaching stockpiled ore-reject material provided 124 t of the cobalt produced (Minara Resources Ltd., 2010, p. 18–19).

In late 2008, OJSC MMC Norilsk Nickel placed the Cawse nickel laterite mine and processing plant, the Silver Swan underground nickel sulfide mine, and the Waterloo underground nickel sulfide mine on indefinite care-and-maintenance status. In early 2009, Norilsk suspended operations at its remaining Western Australian nickel operations—the Black Swan and Lake Johnston nickel sulfide mines and mills—and placed them on care-and-maintenance status (OJSC MMC Norilsk Nickel, 2009).

Panoramic Resources Ltd. produced concentrates containing 420 t of cobalt (408 t in 2008) from its Savannah underground nickel-copper sulfide mine operation in Western Australia. The concentrates were shipped to Jinchuan's operations in China under a long-term offtake agreement (Panoramic Resources Ltd., 2009, p. 2; 2010, p. 2).

China Minmetals Non-Ferrous Metals Co., Ltd. acquired the Avebury nickel sulfide mine in Tasmania and the Century zinc mine in northern Queensland from OZ Minerals Ltd. Prior to being placed on care-and-maintenance status in late 2008, nickel concentrate from Avebury was shipped to Jinchuan under an offtake agreement. Zinc concentrates produced from the Century Mine are shipped to Nyrstar NV's Budel smelter in the Netherlands, where cobalt was recovered as filter cake (OZ Minerals Ltd., 2009).

At yearend, Fox Resources Ltd. announced that it would restart production at its Radio Hill operation near Karratha, Western Australia. Fox planned to process stockpiled nickel-copper sulfide ore using bacterial heap leaching. The Radio Hill mine and mill remained on care-and-maintenance status (Fox Resources Ltd., 2010, p. 1).

Xstrata Nickel Australasia produced 459 t of cobalt in nickel sulfide concentrates from the Cosmos and Sinclair operations in Western Australia in 2009 (120 t during the 11 months of ownership in 2008) (Xstrata plc, 2010b).

Belgium.—According to the Cobalt Development Institute (2010a), Umicore's 2009 cobalt refinery production decreased to 2,150 t from 3,020 t produced in 2008. Umicore converted cobalt metal, residues, and other cobalt-bearing materials into a wide range of cobalt specialty products, including metal powders, hydroxides, oxides, salts, and compounds. Umicore's cobalt refining took place at plants in Olen, Belgium, and Ganzhou, China. The company's cobalt processing plants were in Arab, AL, and Laurinburg, NC, in the United States; Bruges, Belgium; Fort Saskatchewan, Alberta, Canada; Jiangmen and Shanghai, China; and Cheonan, Republic of Korea. In 2009, Minnesota, refurbishing the crushing and grinding equipment in the company's nearby Erie plant, and adding a new beneficiation circuit and hydrometallurgical plant. The final products of the project would be copper cathode, a nickel-cobalt mixed hydroxide, and a precipitate of PGMs and gold. PolyMet planned to develop the project in stages and sell either a bulk concentrate or separate copper and nickel concentrates during the construction and commissioning of the hydrometallurgical plant (table 8). PolyMet and Swiss trading firm Glencore International AG had a strategic partnership whereby Glencore would invest in Polymet and purchase or market NorthMet's concentrates, intermediate products, and metal (PolyMet Mining Corp., 2009, p. 9, 13, 15–17, 27).

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Panoramic Resources Ltd. produced concentrates containing 420 t of cobalt (408 t in 2008) from its Savannah underground nickel-copper sulfide mine operation in Western Australia. The concentrates were shipped to Jinchuan's operations in China under a long-term offtake agreement (Panoramic Resources Ltd., 2009, p. 2; 2010, p. 2).

China Minmetals Non-Ferrous Metals Co., Ltd. acquired the Avebury nickel sulfide mine in Tasmania and the Century zinc mine in northern Queensland from OZ Minerals Ltd. Prior to being placed on care-and-maintenance status in late 2008, nickel concentrate from Avebury was shipped to Jinchuan under an offtake agreement. Zinc concentrates produced from the Century Mine are shipped to Nyrstar NV's Budel smelter in the Netherlands, where cobalt was recovered as filter cake (OZ Minerals Ltd., 2009).

At yearend, Fox Resources Ltd. announced that it would restart production at its Radio Hill operation near Karratha, Western Australia. Fox planned to process stockpiled nickel-copper sulfide ore using bacterial heap leaching. The Radio Hill mine and mill remained on care-and-maintenance status (Fox Resources Ltd., 2010, p. 1).

Xstrata Nickel Australasia produced 459 t of cobalt in nickel sulfide concentrates from the Cosmos and Sinclair operations in Western Australia in 2009 (120 t during the 11 months of ownership in 2008) (Xstrata plc, 2010b).

Belgium.—According to the Cobalt Development Institute (2010a), Umicore's 2009 cobalt refinery production decreased to 2,150 t from 3,020 t produced in 2008. Umicore converted cobalt metal, residues, and other cobalt-bearing materials into a wide range of cobalt specialty products, including metal powders, hydroxides, oxides, salts, and compounds. Umicore's cobalt refining took place at plants in Olen, Belgium, and Ganzhou, China. The company's cobalt processing plants were in Arab, AL, and Laurinburg, NC, in the United States; Bruges, Belgium; Fort Saskatchewan, Alberta, Canada; Jiangmen and Shanghai, China; and Cheonan, Republic of Korea. In 2009, Umicore expanded the production capability of its plants in Cheonan and Jiangmen to include nickel-manganese-cobalt cathode materials for lithium-ion batteries, and announced a plan to build an industrial scale recycling facility for spent rechargeable batteries in Hoboken, Belgium (n.v. Umicore, s.a., 2009; 2010, p. 14).

Botswana.—Tati Nickel Mining Co. Pty. Ltd. (a Norilsk subsidiary) mined the Phoenix open pit and produced nickel-copper sulfide concentrates, which were toll-smelted by BCL Ltd. in Botswana (OJSC MMC Norilsk Nickel, 2010, p. 20).

Brazil.—Votorantim Metais Níquel S.A. produced cobalt cathode at its refinery in Sao Miguel Paulista, Sao Paulo State, from lateritic nickel-cobalt ore mined from Niquelandia, Goias State. The company also produced nickel matte, primarily from sulfide ores mined and smelted at Fortaleza de Minas, Minas Gerais State. During the fourth quarter of 2009, Votorantim received nickel sulfide concentrate from Mirabela Nickel Ltd.

Mirabela Nickel began production from its Santa Rita open pit nickel sulfide mine and concentrator in Bahia State, and by yearend produced 14 t of cobalt in concentrate. All concentrate produced from Santa Rita was committed via offtake agreements with Votorantim (50%) and Norilsk (50%) through 2014 (Mirabela Nickel Ltd., 2010).

Canada.—Vale Inco Ltd. produced 1,575 t of cobalt in 2009, 44% less than the 2,828 t produced in 2008. The decrease in production was the result of labor strikes at its operations in Sudbury from July through yearend and Voisey's Bay from August through yearend. Vale reported production in the form of cathode, 639 t, from its Port Colborne, Ontario, refinery; cobalt hydrate, 554 t, from its Thompson, Manitoba, refinery; and cobalt contained in unrefined products such as nickel concentrates, 491 t. Vale's cobalt originated from nickel sulfide ores from company mines at Sudbury, Ontario; Thompson, Manitoba; and Voisey's Bay in northeastern Labrador; and purchased feedstocks, including nickel sulfide ore from FNX Mining Co. Inc.'s Sudbury operations. Vale reported the following distribution of sources for its cobalt production: Ontario, 359 t (804 t in 2008); Manitoba, 181 t (168 t in 2008); Voisey's Bay, 971 t (1,695 t in 2008); and external sources, 64 t (161 t in 2008) (Vale S.A., 2010, p. 32–33, 43–44).

Xstrata Nickel produced 277 t of cobalt in concentrates from mines at Sudbury (538 t in 2008), 73 t of cobalt in concentrate from its Montcalm Mine northwest of Timmins, Ontario (338 t in 2008), and 586 t of cobalt in concentrate from its Raglan Mine in Quebec (512 t in 2008). Mine production from Sudbury was lower than that of 2008 because of the closure of several high-cost, end-of-life mines but included production from the newly started Nickel Rim South Mine. Production from Montcalm was suspended after the first quarter because of structural damage to the mine. Nickel-copper matte containing 2,476 t of cobalt was produced at the company's Sudbury smelter (2,648 t in 2008); this was refined at Xstrata's Nikkelverk refinery in Norway. Some of the cobalt in the matte originated from ores produced at company mines and some originated from custom feed materials, which were primarily nickel concentrates and nickel-copper-cobalt secondary materials (scrap). Custom feed from mining operations included nickel sulfide ores from URSA Major Minerals Inc.'s Shakespeare Mine in Ontario and First Nickel Inc.'s Lockerby Mine in Sudbury, and nickel sulfide concentrates produced by Crowflight Minerals Inc.'s Bucko Lake nickel mine in the Thompson Nickel Belt of Manitoba and Liberty Mines Inc. in Ontario. Secondary custom feed materials included battery-manufacturing scrap, high-grade slags, metal residues, smelter byproducts, spent batteries and catalysts, superalloy and other alloy scrap, and other secondary materials (Tollinsky, 2008; Xstrata Nickel, 2008, p. 9–11, 21; URSA Major Minerals Inc., 2009; Xstrata plc, 2010b).

The Fort Saskatchewan refinery of the joint venture of Sherritt International Corp. and General Nickel Co. S.A. produced a record 3,721 t of cobalt as metal powder and briquettes in 2009, 9% more than the 3,428 t produced in 2008. Approximately 93% of the cobalt was from nickel-cobalt mixed sulfides from the joint venture's operations at Moa Bay, Cuba; the remainder was from purchased feed materials. Limited activity related to the phase 2 expansion of the refinery took place during the year (table 8). As a result of a United States embargo on imports of products originating from Cuba, cobalt and nickel produced by Sherritt cannot be sold to customers in the United States (Sherritt International Corp., 2010, p. 8, 10).

FNX mined ore from sulfide deposits in Sudbury. In 2009, the company shifted its focus from nickel to copper, and the payable cobalt production decreased to 4 t from 75 t in 2008. First Nickel's Lockerby Mine was on care-and-maintenance status all year. The company's sales of payable cobalt in concentrates decreased to 4 t from 33 t in 2008. In the summer of 2009, Liberty Mines resumed production from its Redstone Mine southeast of Timmins, Ontario, and development of the nearby McWatters Mine. Nickel sulfide ore from the mines was processed at the company's Redstone Mill; Liberty had agreements to sell the resulting concentrate to Xstrata Nickel in Sudbury and Jilin Jien Nickel Industry Company Ltd. in China (First Nickel Inc., 2010, p. 3–4, 18; FNX Mining Company Inc., 2010, p. 8, 10; Liberty Mines Inc., 2010a, p. 27, 2010b, p. 1–2).

China.—China's production of refined cobalt was nearly 24,000 t, which made it the world's leading producer. In 2009, only a small portion of China's cobalt production originated from domestic mines. Most of the production was from imported ores, concentrates, and intermediate materials; the remainder was from stocks and scrap. Most of the imported raw materials were from Congo (Kinshasa). One analyst estimated that China imported 24,900 t of cobalt contained in ores, concentrates, and semirefined materials in 2009, up from 21,400 t in 2008. China's imports of cobalt ores and concentrates and semirefined materials both increased in 2009 compared with those of 2008 (CRU International Ltd., 2010, p. 7; Xu, 2010, p. 5).

The number of companies refining and (or) processing cobalt in China has been estimated to be as many as 120. The leading four refiners were Jinchuan, Zhejiang Huayou Cobalt Nickel Materials Co., Ltd., Zhejiang Galico Cobalt & Nickel Material Co., Ltd., and Ganzhou Yi Hao Umicore Industries, listed in descending order of 2009 estimated cobalt production. Jinchuan produced cobalt as cathode and other products from its refinery at Jinchang, Gansu Province. By 2009, the refinery's cobalt production capacity had been increased to 10,000 t/yr. Some of Jinchuan's cobalt production was from domestic nickel-copper-cobalt sulfide ores mined and refined at Jinchang and some was from other cobalt or nickel feeds. Jinchuan's other feeds included cobalt intermediates (chemical compounds), which were either imported or produced in China from imported concentrates; nickel-copper concentrates from Australia, Spain, and Zambia; nickel concentrates from Australia; and nickel matte from BHP Billiton (Li, 2007; Metal Bulletin Daily, 2009a; Yang, 2009; CRU International Ltd., 2010, p. 4, 6).

In 2009, the Chinese Government reversed its ban on toll processing cobalt materials. The reversal allowed companies to import cobalt concentrates and intermediates produced by hydrometallurgical methods for the production of cobalt metal, metal powder, and salts for export. It was intended to support Chinese producers by enabling them to rely less on the domestic market for the sale of their products (Beijing Antaike Information Development Co., Ltd., 2009).

Congo (Kinshasa).—Congo (Kinshasa) was the world's leading producer of mined cobalt. Some of the country's cobalt mine production was from copper-cobalt ores mined by traditional methods, and some was gathered by tens of thousands of artisanal miners hand-picking cobalt-rich ores. The hand-picked ores were either exported, primarily to China and India, or processed at numerous plants within Congo (Kinshasa) to semirefined materials such as cobalt carbonate or cobalt-bearing alloys. As discussed in the "China" section of this report, exports of cobalt materials to China increased in 2009 compared with those of 2008. In addition, the Government of Katanga Province, where copper and cobalt were mined, removed a ban on exports of cobalt concentrates to neighboring Zambia (Metal Bulletin, 2009a).

The Government of Congo (Kinshasa) nearly completed its review of mining contracts signed between private companies and the Government or Government-owned companies. The review, which began in 2007, was intended to evaluate whether each contract gave a fair share of its revenues to the country and to determine whether it should be maintained, renegotiated, or terminated. At yearend, contracts on two copper-cobalt projects—the Kolwezi Tailings project, which was being developed by First Quantum Ltd., and the Tenke Fungurume project, which was developed by Freeport-McMoRan Copper & Gold Inc. (FCX)—had not yet been finalized (First Quantum Minerals Ltd., 2010, p. 35–37; Freeport-McMoRan Copper & Gold Inc., 2010a, p. 22, 91).

The Government of Congo (Kinshasa) signed an amended multibillion dollar cooperation agreement with a group of Chinese enterprises led by China Railway Group and Sinohydro Corp. Under the agreement, the Chinese consortium would invest in the construction and (or) upgrading of infrastructure in exchange for access to deposits containing a potential 10.6 million metric tons of copper and 620,000 metric tons of cobalt. In 2009, Sicomines Sarl, the joint venture between the Chinese consortium (68%) and State-owned producer La Générale des Carrières et des Mines (Gécamines) (32%), reportedly completed a feasibility study on developing the deposits (table 8) (Reuters Ltd., 2009a).

S.A. Groupe George Forrest signed various agreements with Korea Water Resources Corp., Alfonso Rowemberg Korea Ltd., and Korea Resources Corp. Under the agreements, the companies were to rehabilitate existing energy infrastructure, to build new dams, water systems, and hydroelectric installations, and to examine opportunities for investments, acquisitions, or joint business in the mining industry. Congo (Kinshasa) reportedly was to provide access to mineral resources including 430,000 t/yr of copper, 21,500 t/yr of cobalt, and 2,000 t/yr of uranium (George Forrest International S.A., 2009; Park, 2009).

Gécamines produced 415 t of refined cobalt, compared with an estimated 300 t produced in 2008 (Cobalt Development Institute, 2010a).

Katanga Mining Ltd.'s production of cobalt cathode increased to 2,534 t from 749 t in 2008 as the company ramped up operations at its Luilu refinery. The refinery processed concentrates produced from ore extracted from Katanga's Kamoto underground mine and T17 open pit. By yearend, Katanga had begun commercial production from the second phase of its program to rehabilitate its operations and announced a revised accelerated development plan for phase 3, which included restarting production from the large Kamoto-East Olivera Virgule (KOV) open pit mine and increasing capacity at the Luilu refinery (table 8). Glencore had an offtake agreement for all of Katanga's copper and cobalt output (Katanga Mining Ltd., 2010, p. 2–3, 7, 20, 34–35).

Central African Mining & Exploration Company plc (CAMEC) restarted cobalt mining at Mukondo Mountain and copper refining at its Luita solvent extraction–electrowinning (SX–EW) plant. Production from Luita during the 12-month period ending March 31, 2009, included 4,631 t of cobalt in carbonate, a 61% increase from the 12-month period ending March 31, 2008. Following the fiscal yearend, Luita's monthly production of cobalt in carbonate reached 710 t. CAMEC made improvements to its Kakanda concentrator, raising the capacity to approximately 6,000 t/yr of cobalt contained in concentrates, and continued to build the Luita plant on a modular basis, reporting that it was to have a design capacity of 3,200 t/yr of cobalt cathode. CAMEC entered into a long-term agreement to sell an estimated 6,000 to 8,000 t/yr of cobalt in concentrate from Mukondo Mountain to Zhejiang Galico in China. Late in the year, however, CAMEC was acquired by Eurasian Natural Resources Corp. PLC (Central African Mining & Exploration Company plc, 2009a; 2009b, p. 9, 11, 17–18; Eurasian Natural Resources Corp. PLC, 2010, p. 2).

Gécamines and L'Enterprise Générale Malta Forrest S.P.R.L. temporarily suspended production of copper-cobalt concentrate from the Luiswishi Mine and Kipushi concentrator in late 2008 in response to low demand and prices. As a result, 2009 production from the mine was only 437 t of cobalt in concentrate (Harrison, 2008; La Générale des Carrières et des Mines, undated).

The Big Hill smelter at Lubumbashi [operated as a joint venture between Gécamines, OM Group, Inc. (OMG), and S.A. Groupe George Forrest] processed stockpiled slag to produce a cobalt-copper alloy, which was sold to OMG's Kokkola refinery. Production of cobalt contained in alloy during recent years was as follows: 5,593 t in 2007; 5,545 t in 2008; and 4,590 t in 2009 (George Forrest International S.A., 2010).

FCX completed construction of the initial phase of the Tenke Fungurume project and began producing copper cathode. The project, between the towns of Kolwezi and Likasi, comprised open pit mining of sediment-hosted copper-cobalt ore, recovering the metals by agitation leaching, and SX–EW to produce copper cathode and cobalt hydroxide. The first phase of the project was designed to produce more than 8,000 t/yr of contained cobalt. Although the cobalt plant was commissioned in September, FCX was still addressing startup and quality issues at yearend; the company's 2009 sales included approximately 1,360 t of cobalt. Late in the year, FCX began a feasibility study on the second phase of the project, which included optimizing the current plant and potentially expanding its capacity by approximately 50%. Lundin Mining Corp. and Gécamines had minority interests in Tenke Fungurume (Freeport-McMoRan Copper & Gold Inc., 2010a, p. 2, 21–22, 91; 2010b, p. 36).

ROQ Mining Sprl mined copper-cobalt ores from the Goma 1 and Goma 2 open pit deposits southwest of Kolwezi. In 2009, the company expected to produce about 1,000 t of cobalt in concentrate, which would be processed offsite to cobalt hydroxide or aliage blanc prior to export (Levy, 2009, p. 9–11).

Chemaf SPRL mined copper-cobalt oxide ores from the Etoile open pit mine and produced approximately 3,000 t of cobalt contained in carbonate at its nearby Lubumbashi plant (Metal Bulletin, 2010).

Metorex Ltd.'s Ruashi operation north of Lubumbashi comprised mining copper-cobalt oxides ores from open pits and milling and processing the ore in the newly commissioned Ruashi phase 2 SX–EW refinery. In 2009, the plant produced 2,198 t of cobalt in carbonate, which was sold to Jinchuan under an offtake agreement. Gécamines had a 25% interest in the Ruashi operation (Metorex Ltd., 2009a, p. 12–13; 2009b; 2010).

Cuba.—The Moa Nickel S.A. (part of the 50–50 joint venture between Sherritt and General Nickel) mined nickel-cobalt laterites at Moa Bay, Holguin Province, and produced mixed sulfides, which were sent to the joint venture's Fort Saskatchewan refinery in Canada. In 2009, the mixed sulfides contained a record 37,328 t of nickel and cobalt, 6% more than the 35,119 t produced in 2008. The increase in production was mainly attributed to operating the Moa plant for a full year following an expansion that was completed during 2008. Most activity related to further expansion of the plant remained under suspension during the year (table 8) (Sherritt International Corp., 2010, p. 8, 10).

The Ernesto Che Guevara and Rene Ramos Latour Mining and Metallurgical Combines also mined nickel-cobalt laterites and produced mixed nickel-cobalt sulfides in Holguin Province. Nickel and cobalt of Cuban origin cannot be imported into the United States because of a United States embargo on imports from Cuba.

Finland.—OMG's production of refined cobalt, as metal powders, briquettes, oxides, and compounds, was 7% lower than that of 2008. The company's Kokkola Chemicals Oy refinery processed raw materials sourced primarily from Congo (Kinshasa), Finland, and Russia. Most of the feed was cobalt-copper alloy from the Big Hill smelter in Congo (Kinshasa) and crude cobalt hydroxide and crude cobalt sulfate from Norilsk's nickel operations in Russia. OMG also refined cobalt solution from Norilsk's Harjavalta nickel refinery in Finland and materials from other sources, such as ores and concentrates, sulfides, metallic feeds, and secondary materials (scrap) (OM Group, Inc., 2010, p. 5, 29).

Talvivaara Mining Co. Plc worked to ramp up and to optimize production from its polymetallic sulfide mine and bioheap-leaching operation in Sotkamo in central Finland. During the year, the company produced commercial quantities of nickel; production of commercial quantities of cobalt and copper was expected to begin in 2011. Talvivaara announced that it planned to increase the operation's production capacity (table 8). The nickel-cobalt sulfide product from Talvivaara was committed to Norilsk for processing at Harjavalta under a 10-year offtake agreement (Talvivaara Mining Co. Plc, 2010, p. 23, 86).

Belvedere Resources Ltd.'s Hitura and Sarkiniemi nickel-copper sulfide mines remained on care-and-maintenance status throughout the year. Finn Nickel Ltd. (Belvedere's nickel production subsidiary) filed for bankruptcy at midyear, after which Belvedere sold some of Finn Nickel's assets—the Luikonlahti Mill and the Hautalampi and Valkeisenranta nickel properties—to Vulcan Resources Ltd. (Belvedere Resources Ltd., 2009, p. 1, 3).

France.—The Eramet Group's production of cobalt chloride from its refinery at Sandouville was 18% more than that produced in 2008. Feed for the refinery was nickel matte imported from Eramet subsidiary Le Nickel SLN's Doniambo smelter in New Caledonia (Cobalt Development Institute, 2010a).

India.—According to an estimate by the Cobalt Development Institute (2010a), India's cobalt production increased by 17% from that of 2008. Nicomet Industries Ltd. and Rubamin Ltd. were India's leading cobalt producers.

Indonesia.—PT International Nickel Indonesia Tbk (PT Inco) produced nickel matte from lateritic ores at its integrated mining and smelting operation near Sorowako on Sulawesi Island. Cobalt contained in matte deliveries decreased to 891 t from 981 t in 2008. PT Inco sold its entire matte production to Vale Inco (80%) and Sumitomo Metal Mining Co., Ltd. (20%) under long-term contracts (PT International Nickel Indonesia Tbk, 2010, p. 111, 113).

PT Antam Tbk exported lateritic nickel-cobalt ore to Queensland Nickel's Yabulu refinery for processing (CRU International Ltd., 2010, p. 4).

Japan.—Sumitomo's production of electrolytic cobalt at its Niihama nickel refinery increased by 24% from that of 2008. The refinery processed nickel-cobalt mixed sulfide feed from the Coral Bay Nickel Corp. plant in the Philippines and nickel matte from PT Inco in Indonesia and BHP Billiton's Nickel West operations (CRU International Ltd., 2010, p. 4; Cobalt Development Institute, 2010a).

Japan Oil, Gas and Metals National Corp. (JOGMEC) reportedly held tenders to purchase 130 t of cobalt metal for its national rare-metals stockpile; results of the tenders were not released (Ryan's Notes, 2009).

Korea, Republic of.—The Korean Government reportedly planned to secure a strategic stockpile of various metals, including 84 t of cobalt (Metal-Pages, 2009b).

Morocco.—Cie. de Tifnout Tighanimine (CTT) produced cobalt hydroxide at its processing plant at Bouazzer, and cobalt cathode and oxide at its Guemassa hydrometallurgical refinery north of Marrakech. CTT's cobalt production was from domestic cobalt-arsenic deposits and heterogenite imported from Congo (Kinshasa).

New Caledonia.—Lateritic nickel-cobalt ore was exported to Queensland Nickel's Yabulu refinery for processing. Nickel matte from Le Nickel SLN's Doniambo smelter was sent to Eramet's refinery in Sandouville, France, where nickel products and cobalt chloride were produced.

Norway.—Xstrata Nickel's production of cobalt cathode at its Nikkelverk refinery was 6% less than that of 2008. The cobalt originated from Xstrata Nickel mines in Australia and Canada, recycled materials, and custom feeds, which included matte from Botswana processed under a long-term agreement with BCL, and copper-cobalt white alloy purchased from Glencore. The decrease in refined cobalt production was similar in amount to the decrease in cobalt contained in matte produced from Xstrata Nickel's Sudbury operations, which was attributed to lower volumes of cobalt-rich third-party feed. Glencore is the sole distributor of Xstrata's cobalt (Xstrata plc, 2010a, p. 19, 29, 80–81, 203; 2010b).

Philippines.—Coral Bay Nickel (a joint venture between Sumitomo, Mitsui & Co., Ltd., Sojitz Corp., and Rio Tuba Nickel Mining Corp.) began production from a second high-pressure acid-leaching plant at the Rio Tuba nickel laterite mine on Palawan Island. The combined capacity of the two plants was an estimated 1,500 t/yr of cobalt in nickel-cobalt mixed sulfide. All the mixed sulfide produced by Coral Bay Nickel was refined by Sumitomo in Japan (Metal Bulletin Daily, 2009b).

Toledo Mining Corp. plc exported lateritic nickel-cobalt ore from its Berong Mine to Queensland Nickel's Yabulu refinery for processing (CRU International Ltd., 2010, p. 4).

Russia.—Norilsk, Russia's leading producer of cobalt, conducted nickel-copper sulfide mining and refining on the Taimyr and Kola Peninsulas. Cobalt from ores mined on the Taimyr Peninsula was refined to metal at the company's nickel plant at Norilsk. According to the Cobalt Development Institute (2010a), Norilsk produced 2,352 t of refined cobalt, 6% less than the 2,502 t produced in 2008. Cobalt from ores mined on the Kola Peninsula was extracted as an intermediate product at the company's nickel plant in Monchegorsk and sent to OMG's operations in Finland under a 5-year supply agreement that began in 2007. Under this agreement, Norilsk was to supply OMG with up to 2,500 t/yr cobalt metal, up to 2,500 t/yr of cobalt contained in cobalt hydroxide concentrate, and up to 1,500 t/yr of cobalt contained in cobalt sulfate solution. Norilsk continued to study the feasibility of producing electrolytic cobalt at Monchegorsk (OJSC MMC Norilsk Nickel, 2010, p. 61).

South Africa.—Cobalt was produced as a byproduct from some of South Africa's PGM mines and from the Nkomati nickel sulfide mine. Nkomati (a joint venture of African Rainbow Minerals Ltd. and Norilsk) produced 333 t of cobalt in 2009, compared with 296 t in 2008. During the year, the joint-venture partners completed the first phase of an expansion project (table 8) (African Rainbow Minerals Ltd., 2009, p. 35; 2010, p. 60–61).

Two companies produced refined cobalt as a byproduct of platinum refining. Rustenburg Base Metals Refiners (Proprietary) Ltd. (a subsidiary of Anglo American plc) produced cobalt sulfate at its refinery near Rustenburg, Northwest Province. The company was increasing the nickel capacity of its base-metals refinery to 33,000 t/yr from 21,500 t/yr; an equivalent increase in cobalt capacity was expected (table 8). Impala Platinum Ltd. produced cobalt metal powder at its base-metals refinery near Springs, Gauteng Province. Some of the cobalt produced by Impala was recovered from concentrates produced at the Mimosa platinum mine in Zimbabwe.

Spain.—Lundin Mining Corp.'s Aguablanca open pit nickel sulfide mine and processing plant in Badajoz Province produced nickel-copper concentrate containing an estimated 200 t of cobalt, which it sold to Glencore under a long-term sales agreement (Lundin Mining Corp., 2010).

Uganda.—Kasese Cobalt Co. Ltd. produced cobalt cathode from stockpiled pyrite concentrates using a bacterial leaching-SX-EW process at its cobalt refinery in southwestern Uganda. At current production rates, the stockpile was expected to be exhausted in 2013. The company reportedly was negotiating to acquire tailings from the nearby Kilembe Mine, so that the refinery could continue operating (Metal Bulletin, 2009b).

Zambia.—Mopani Copper Mines Plc produced approximately 1,300 t of cobalt metal at its Nkana cobalt refinery, 7% less than the 1,400 t produced in 2008. Most of the cobalt originated from the company's Nkana underground copper-cobalt mine (First Quantum Minerals Ltd., 2010, p. 4).

Chambishi Metals plc produced 235 t of cobalt metal at its Chambishi refinery, a significant decrease from the 2,591 t produced in 2008. Production from the refinery was suspended in late 2008 in response to low cobalt and copper prices. The operation remained on care-and-maintenance status until early November, when it reportedly began toll-refining material imported from the Tenke Fungurume project in Congo (Kinshasa). Chambishi Metals planned to process feed from multiple sources in Congo (Kinshasa) and Zambia and would not resume processing slag from the stockpile at Nkana until the price of cobalt increased to $22 per pound (Platts Metals Week, 2009; Reuters Ltd., 2009b; Cobalt Development Institute, 2010a).

Konkola Copper Mines Plc (KCM) mined copper ores from its Nchanga and Konkola operations. The company's main source of cobalt was its Nchanga open pit. Cobalt in concentrate was processed to an alloy with a design specification of 63% copper, 23.6% iron, and 6.3% cobalt at the company's Nchanga copper smelter. KCM planned to expand the cobalt capacity of the smelter (table 8) (Metal Bulletin, 2009c; Vedanta Resources plc, 2009, p. 17).

China Nonferrous Metal Mining (Group) Co. Ltd. (CNMC) purchased the Baluba copper-cobalt mine and the Muliashi copper-cobalt project from Luanshya Copper Mines plc (a unit of Enya Holdings BV of Amsterdam, Netherlands). At yearend, NFC Africa Mining plc (85% CNMC and 15%

ZCCM Investments Holdings Plc.) restarted production at the Baluba Mine. The mine, which had been placed on care-and-maintenance status in late 2008 in response to low copper prices, reportedly had the capacity to produce 4,000 t/yr of cobalt (Metal-Pages, 2009a).

Metorex produced 39 t of cobalt in cobalt carbonate at its Sable copper electrowinning plant near Kabwe, compared with 388 t produced in 2008. The decrease in production was because Metorex discontinued its Ruashi phase I operation in Congo (Kinshasa) in December 2008 and ceased shipments of copper-cobalt concentrates to Sable. The Sable plant continued to process copper-cobalt concentrates from third party suppliers (Metorex Ltd., 2009a, p. 5, 13; 2009b; 2010).

In early 2009, Albidon Ltd. ceased production at its Munali nickel mine in southern Zambia, placed the concentrator on care-and-maintenance status, and went into voluntary administration. Jinchuan, Albidon's major shareholder, restructured and recapitalized the company, and by yearend underground mining operations had resumed at Munali. Nickel-copper-cobalt-PGM sulfide concentrate from Munali is committed to Jinchuan under a life-of-mine offtake agreement (Albidon Ltd., 2010).

Chambishi Copper Smelter Ltd. (a joint venture between China Nonferrous Metal Mining Group Co. Ltd. (CNMC) and Yunnan Copper Industry Group Co. Ltd.) began production at its newly constructed smelter at CNMC's Chambishi Mine. The smelter had the capacity to produce 150,000 t/yr of copper and 2,800 t/yr of cobalt. Equinox Minerals Ltd. had a 5-year offtake agreement with Chambishi Copper Smelter to process copper concentrates from its newly opened Lumwana Mine. Equinox also sent Lumwana concentrates to KCM's Nchanga smelter for processing (Interfax China Ltd., 2008; Equinox Minerals Ltd., 2010, p. 14).

Zimbabwe.—In late 2008, Bindura Nickel Corp. placed its Shangani and Trojan nickel sulfide mines on care-and-maintenance status in response to the decrease in nickel prices and difficult economic conditions in Zimbabwe. The company operated the nickel smelter and refinery until all concentrate stocks were depleted in March 2009, and investigated options for restarting operations. Cobalt hydroxide is one of the products from the company's refinery (Mwana Africa PLC, 2009, p. 5). Aquarius Platinum Ltd. produced 74 t of cobalt from its Mimosa platinum mine (64 t in 2008). The concentrates were refined by Impala in South Africa (Aquarius Platinum Ltd., 2009, p. 15; 2010, p. 12).

Outlook

The global economic downturn that began in late 2008 resulted in reduced demand for cobalt in 2008 and 2009, affecting all major end-use sectors. As global economic conditions showed signs of recovery in 2009 and into 2010, demand for cobalt improved (Collignon, 2010, p. 8–11).

During the first half of 2010, the world availability of refined cobalt (as measured by production and U.S. Government shipments) was 49% higher than that of the first half of 2009. China showed the largest increase in production; production from Congo (Kinshasa), Japan, and Zambia also increased significantly. In the next few years, global increases in supply from existing producers and new projects are forecast to outpace increases in consumption. If an oversupply of cobalt takes place, it could lead to a downward trend in prices (Cobalt Development Institute, 2010b).

The LME's cobalt contract was launched in February 2010. As the year progressed, the number of producers' cobalt brands approved for listing on the exchange increased and the LME added Antwerp, Belgium, as a fourth delivery point. The LME cash price for cobalt generally followed the same trend as Metal Bulletin's spot price for 99.3% cobalt. Some companies began to use the LME price as a reference for their purchases or sales.

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TABLE 1

SALIENT COBALT STATISTICS[1]

(Metric tons, cobalt content, unless otherwise specified)

	2005	2006	2007	2008	2009
United States:					
Consumption:					
Reported	9,150	9,280	9,320	8,810	7,460
Apparent	11,800	11,000	9,630	10,100	7,520
Imports for consumption	11,100	11,600	10,300	10,700	7,680
Exports	2,440	2,850	3,100	2,850	2,440
Stocks, December 31:					
Industry[2]	705	737	620	582	587
U.S. Government[3]	1,550	1,290	676	473	293
Price, metal[4] dollars per pound	15.96	17.22	30.55	39.01	17.86
World, production:					
Mine	65,200 [r]	68,900 [r]	71,500 [r]	76,300 [r]	72,300 [e]
Refinery	54,100	53,800	53,300	57,200 [r]	59,800

[e] Estimated. [r] Revised.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Stocks held by cobalt processors and consumers.

[3] Defense National Stockpile Center. Data for 2005–06 include material committed for sale pending shipment; data for 2007–09 are uncommitted material only.

[4] Annual average U.S. spot price for minimum 99.8% cobalt cathode reported by Platts Metals Week.

TABLE 2

U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE SALES AND SHIPMENTS[1]

(Metric tons, cobalt content)

	2008	2009
Sales:		
Fiscal year[2]	481	187
Calendar year	203	169
Shipments:[3]		
Fiscal year[2]	493	192
Calendar year	203	180

[1] Data are rounded to no more than three significant digits.

[2] Twelve-month period ending September 30 of year stated.

[3] Calculated from yearend inventory levels.Yearend data are uncommitted material only.

Source: Defense National Stockpile Center.

TABLE 3

U.S. REPORTED CONSUMPTION AND STOCKS OF COBALT[1, 2]

(Metric tons, cobalt content)

	2008	2009
Consumption by end use:		
Steels	604	510
Superalloys	4,320	3,680
Alloys, excludes steels and superalloys:		
Magnetic alloys	368	295
Other alloys[3]	226	221
Cemented carbides[4]	827	503
Chemical and ceramic uses	2,410	2,190
Miscellaneous and unspecified	63	63
Total	8,810	7,460
Consumption by form:		
Chemical compounds, organic and inorganic[5]	2,250	2,130
Metal	4,640	3,540
Purchased scrap	1,930	1,790
Total	8,810	7,460
Stocks, December 31:[6]		
Chemical compounds, organic and inorganic[5]	203	171
Metal	307	347
Purchased scrap	72	68
Total	582	587

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes estimates.

[3] Includes nonferrous alloys, welding materials, and wear-resistant alloys.

[4] Includes diamond tool matrices, cemented and sintered carbides, and cast carbide dies or parts.

[5] Includes oxides.

[6] Stocks held by cobalt processors and consumers.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY FORM[1]

	2008			2009		
	Gross weight (metric tons)	Cobalt content[2] (metric tons)	Value (thousands)	Gross weight (metric tons)	Cobalt content[2] (metric tons)	Value (thousands)
Metal[3]	8,430	8,430	$618,000	5,870	5,870	$198,000
Oxides and hydroxides	1,110	800	63,400	1,460	1,050	37,500
Other forms:						
Acetates	439	105	3,140	168	40	1,220
Carbonates	1,100	508	31,800	972	447	18,000
Chlorides	177	44	1,280	231	58	2,220
Sulfates	2,990	806	13,700	760	205	5,900
Grand total	14,200	10,700	732,000	9,470	7,680	262,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Estimated from gross weights.

[3] Unwrought cobalt, excluding alloys and waste and scrap.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY COUNTRY[1]

Country of origin	Metal[2] Gross weight (metric tons)	Metal[2] Cobalt content[4] (metric tons)	Metal[2] Value[5] (thousands)	Oxides and hydroxides Gross weight (metric tons)	Oxides and hydroxides Cobalt content[4] (metric tons)	Oxides and hydroxides Value[5] (thousands)	Other forms[3] Gross weight (metric tons)	Other forms[3] Cobalt content[4] (metric tons)	Other forms[3] Value[5] (thousands)	Total Gross weight (metric tons)	Total Cobalt content[4] (metric tons)	Total Value[5] (thousands)
2008:												
Argentina	--	--	--	--	--	--	134	34	$538	134	34	$538
Australia	757	757	$60,200	--	--	--	--	--	--	757	757	60,200
Belgium	353	353	21,800	518	373	$28,100	69	22	1,330	939	748	51,300
Brazil	110	110	8,540	--	--	--	219	61	1,270	329	171	9,810
Canada	1,360	1,360	89,100	21	15	1,100	--	--	--	1,380	1,370	90,100
China	1,240	1,240	86,900	252	181	13,800	226	78	5,090	1,710	1,490	106,000
Congo (Kinshasa)	28	28	1,140	--	--	--	--	--	--	28	28	1,140
Finland	441	441	34,300	178	128	11,000	2,760	879	27,400	3,380	1,450	72,600
France	27	27	2,830	(6)	(6)	7	1	(6)	6	28	28	2,840
Germany	13	13	1,040	12	9	1,230	--	--	--	25	21	2,270
India	21	21	1,220	--	--	--	719	194	2,760	740	215	3,980
Japan	143	143	12,300	2	1	106	--	--	--	145	144	12,400
Korea, Republic of	12	12	295	--	--	--	9	4	256	21	16	552
Morocco	444	444	33,100	--	--	--	--	--	--	444	444	33,100
Norway	1,400	1,400	115,000	--	--	--	--	--	--	1,400	1,400	115,000
Russia	1,390	1,390	93,900	--	--	--	--	--	--	1,390	1,390	93,900
South Africa	178	178	17,000	1	1	60	--	--	--	179	178	17,000
Uganda	20	20	1,980	--	--	--	--	--	--	20	20	1,980
United Kingdom	32	32	1,780	119	86	7,480	541	184	10,900	692	302	20,200
Zambia	456	456	35,200	--	--	--	--	--	--	456	456	35,200
Other	8	8	480	8	6	416	28	8	361	44	22	1,260
Total	8,430	8,430	618,000	1,110	800	63,400	4,710	1,460	49,900	14,200	10,700	732,000
2009:												
Australia	380	380	11,600	--	--	--	--	--	--	380	380	11,600
Belgium	99	99	4,560	531	382	16,100	69	24	850	699	505	21,500
Brazil	172	172	5,280	--	--	--	7	2	60	179	173	5,340
Canada	246	246	7,820	471	339	8,140	2	(6)	5	719	586	16,000
China	1,360	1,360	47,800	128	92	3,590	433	150	5,570	1,920	1,600	57,000
Congo (Kinshasa)	101	101	3,170	--	--	--	--	--	--	101	101	3,170
Finland	175	175	7,340	151	108	4,020	1,180	438	16,200	1,510	721	27,600
France	18	18	968	--	--	--	1	(6)	23	19	18	992
Germany	14	14	1,010	4	3	336	--	--	--	18	16	1,340
Hong Kong	--	--	--	14	10	335	--	--	--	14	10	335
India	2	2	47	--	--	--	206	56	1,620	208	58	1,670

See footnotes at end of table.

TABLE 5—Continued

U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY COUNTRY[1]

Country of origin	Metal[2] Gross weight (metric tons)	Metal[2] Cobalt content[4] (metric tons)	Metal[2] Value[5] (thousands)	Oxides and hydroxides Gross weight (metric tons)	Oxides and hydroxides Cobalt content[4] (metric tons)	Oxides and hydroxides Value[5] (thousands)	Other forms[3] Gross weight (metric tons)	Other forms[3] Cobalt content[4] (metric tons)	Other forms[3] Value[5] (thousands)	Total Gross weight (metric tons)	Total Cobalt content[4] (metric tons)	Total Value[5] (thousands)
2009—Continued:												
Japan	273	273	$10,700	3	2	$176	45	12	$374	321	287	$11,300
Morocco	247	247	7,550	--	--	--	--	--	--	247	247	7,550
Norway	1,650	1,650	52,300	--	--	--	--	--	--	1,650	1,650	52,300
Russia	851	851	28,500	--	--	--	--	--	--	851	851	28,500
South Africa	26	26	847	1	1	29	--	--	--	27	26	876
Taiwan	5	5	99	--	--	--	40	9	91	44	14	190
Uganda	30	30	968	--	--	--	--	--	--	30	30	968
United Kingdom	42	42	1,500	149	108	4,580	140	54	2,360	331	204	8,440
Zambia	183	183	5,080	--	--	--	--	--	--	183	183	5,080
Other	7	7	331	9	6	226	8	4	173	24	17	730
Total	5,870	5,870	198,000	1,460	1,050	37,500	2,130	751	27,300	9,470	7,680	262,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Unwrought cobalt, excluding alloys and waste and scrap; includes cobalt cathode and cobalt metal powder; may include intermediate products of cobalt metallurgy.

[3] Includes cobalt acetates, cobalt carbonates, cobalt chlorides, and cobalt sulfates.

[4] Estimated from gross weights.

[5] Customs value.

[6] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 6
U.S. EXPORTS OF COBALT IN 2009, BY COUNTRY[1,2]

Country of destination	Metal[3]		Oxides and hydroxides		Acetates		Chlorides		Total	
	Gross weight (metric tons)	Value[4] (thousands)	Gross weight (metric tons)	Value[4] (thousands)	Gross weight (metric tons)	Value[4] (thousands)	Gross weight (metric tons)	Value[4] (thousands)	Cobalt content[5] (metric tons)	Value[4] (thousands)
Argentina	11	$431	4	$128	--	--	--	--	14	$559
Australia	3	146	(6)	7	9	$34	--	--	6	186
Austria	12	400	--	--	--	--	--	--	12	400
Belgium	146	3,830	53	1,280	100	1,930	--	--	208	7,050
Brazil	1	55	3	103	308	1,690	--	--	77	1,840
Canada	51	2,310	50	1,140	30	317	1	$12	95	3,780
China	152	4,230	(6)	9	18	191	--	--	157	4,430
France	502	16,100	--	--	--	--	1	26	502	16,100
Germany	179	9,180	(6)	8	--	--	2	37	180	9,230
Hong Kong	3	226	(6)	3	28	12	--	--	9	241
India	9	501	--	--	--	--	--	--	9	501
Ireland	598	19,300	(6)	4	--	--	--	--	598	19,300
Italy	9	510	--	--	--	--	--	--	9	510
Japan	228	13,100	16	526	(6)	6	--	--	239	13,600
Korea, Republic of	33	1,230	(6)	3	11	244	5	72	37	1,550
Malaysia	7	116	--	--	--	--	--	--	7	116
Mexico	4	242	76	2,120	123	3,150	(6)	7	89	5,520
Oman	--	--	--	--	20	630	--	--	5	630
Singapore	13	841	2	5	--	--	--	--	14	845
Switzerland	6	285	--	--	--	--	--	--	6	285
Taiwan	18	360	(6)	4	1	10	--	--	18	374
Tunisia	20	810	--	--	--	--	--	--	20	810
United Kingdom	91	1,970	8	69	--	--	--	--	97	2,040
Venezuela	9	295	2	71	--	--	--	--	11	366
Other	12	834	10	71	--	--	1	9	20	914
Total	2,120	77,300	225	5,550	648	8,210	10	163	2,440	91,200

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] In addition to the materials listed, the United States exports cobalt ores and concentrates and wrought cobalt and cobalt articles.

[3] Includes unwrought cobalt, powders, waste and scrap, and mattes and other intermediate products of cobalt metallurgy.

[4] Free alongside ship value.

[5] Estimated from gross weights.

[6] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7
WORLD ANNUAL COBALT REFINERY CAPACITY, DECEMBER 31, 2009[1, 2]

(Metric tons, cobalt content)

Country	Capacity
Australia[e]	6,200
Belgium	1,500
Brazil	1,420
Canada[e]	6,200
China[e]	35,600
Congo (Kinshasa)[e]	10,000
Finland	10,000
France	500
India[e]	2,060
Japan[e]	1,800
Morocco[e]	1,750
Norway	5,200
Russia[e]	6,000
South Africa[e]	800
Uganda	720
Zambia	8,200
Total	98,000

[e] Estimated.

[1] Data are rounded to no more than three significant digits; may not add to total shown.

[2] Includes standby capacity. Refinery products include cobalt metal, metal powders, oxides, and (or) salts.

TABLE 8
COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2014[1, 2]

Projected year of first production	Country	Project and company[3]	Project type[4]	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2009[5]	Australia	Heap-leach expansion Minara Resources Ltd. and Glencore International AG	expansion of demonstration plant	nickel	stockpiled nickel-cobalt laterite ore reject material	750 [e, 6]	Nickel-cobalt solution.
2009[5]	Canada	Fort Saskatchewan expansion Sherritt International Corp.	expansion of existing refinery	do.	nickel-cobalt sulfide	4,600 [e, 6]	Cobalt metal powder and briquettes.
2009[5]	Cuba	Moa Joint Venture Expansion, phase 2 Moa Nickel S.A. (Sherritt International Corp. and General Nickel Co. S.A.)	expansion of existing plant	do.	nickel-cobalt laterite ore	4,300 [e, 6]	Nickel-cobalt sulfide.
2009[5, 7]	Vietnam	Ban Phuc Asian Mineral Resources Ltd. and Son La Mechanical Engineering Joint Stock Company	new mine and beneficiation plant	do.	nickel sulfide ore	170	Nickel concentrate.
2010[r]	Australia	Browns Oxide HNC (Australia) Resources Pty. Ltd.	new mine and relocated and refurbished refinery	copper	copper-cobalt-nickel oxide ore	1,000	Cobalt-nickel carbonate.
2010	do.	Radio Hill Fox Resources Ltd.	new heap-leaching operation	nickel	nickel-copper sulfide ore	NA	Nickel-cobalt carbonate or hydroxide.
2010	China	Nickel-cobalt refinery Jiangxi Rare Earth and Rare Metals Tungsten Group Co. Ltd. and Ipilan joint venture	new refinery	do.	nickel-cobalt hydroxide	600	NA.
2010	do.	Plant expansion Zhejiang Huayou Cobalt Co.	addition of cobalt tetroxide facility	cobalt	cobalt concentrates	8,000 [r, 6]	Cobalt salts.
2010[5]	Congo (Kinshasa)	Kalukundi H & J Swanepoel Famille Trust sprl and La Générale des Carrières et des Mines (Gécamines)	new mine and refinery	copper	copper-cobalt oxide ore	4,200 [r]	Cobalt cathode.
2010	do.	Kipoi, stage I Congo Minerals sprl and La Générale des Carrières et des Mines (Gécamines)	new mine and beneficiation plant	do.	do.	NA	Stockpiled cobalt ore or cobalt concentrate for sale.
2010	do.	Likasi plant Rubamin Ltd.	expansion of existing smelter	do.	copper-cobalt ore	2,000 [6]	Alliage blanc.
2010[r]	do.	Luita SX-EW line Eurasian Natural Resources Corp. PLC	addition to existing plant	cobalt	cobalt in solution	3,200 [8]	Cobalt cathode.
2010[r]	New Caledonia	Vale Inco Nouvelle-Calédonie[9] Vale Inco, Sumic Nickel Netherlands b.v. (Sumitomo Metal Mining Co., Ltd. and Mitsui & Co., Ltd.), and Société de Participation Minière du Sud Calédonien S.A.S.	new mine and HPAL processing plant	nickel	nickel-cobalt laterite ore	4,600 to 5,500	Cobalt carbonate.

See footnotes at end of table.

TABLE 8—Continued

COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2014[1, 2]

Projected year of first production	Country	Project and company[3]	Project type[4]	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2010	Papua New Guinea	Ramu China Metallurgical Construction Group Corp., Jinchuan Group Ltd., Jilin Jien Nickel Industry Co. Ltd., Jiuquan Iron & Steel Group Co. Ltd., Highlands Pacific Ltd., Mineral Resources Development Co.	new mine, beneficiation plant, and HPAL processing plant	nickel	nickel-cobalt laterite ore	3,300	Nickel-cobalt hydroxide.
2010	South Africa	Nkomati Large Scale Expansion African Rainbow Minerals Ltd. and OJSC MMC Norilsk Nickel	expansion of existing mine and beneficiation plant	do.	nickel-copper-cobalt-platinum-group metals sulfide and chromite ores	550 [e, 6]	Nickel concentrate.
2011	Australia	Barnes Hill Proto Resources & Investments Ltd. and Metals Finance Ltd.	new mine and ATML processing plant	do.	nickel-cobalt laterite ore	400 [e]	Nickel-cobalt intermediate.
2011[5]	do.	Mutooroo Havilah Resources NL	new mine, beneficiation plant, and refinery[10]	copper	copper-cobalt sulfide ore	1,200	Cobalt hydroxide.[10]
2011[3]	do.	Niwest GME Resources Ltd.	new mine and heap-leaching operation	nickel	nickel-cobalt laterite ore	1,400	Nickel-cobalt sulfide.
2011[r]	Canada	Lockerby Depth First Nickel Inc.	expansion of existing mine	do.	nickel-copper-cobalt sulfide ore	80 [6]	Nickel-copper-cobalt sulfide ore.
2011[e]	do.	Makwa Mustang Minerals Corp.	new mine and beneficiation plant	do.	nickel-copper-platinum-group metals sulfide ore	150 [e]	Nickel concentrate.
2011[5]	do.	Raglan Mine Xstrata Nickel	expansion of existing mine, stage I	do.	nickel-copper-cobalt-platinum-group metals sulfide ore	NA	Do.
2011[r, 11]	Congo (Kinshasa)	Kolwezi tailings First Quantum Minerals Ltd., La Générale des Carrières et des Mines (Gécamines), Industrial Development Corp., International Finance Corp., and Government of Congo (Kinshasa)	new refinery	copper	copper-cobalt tailings	5,800	Cobalt hydroxide.
2011[r]	do.	Luilu Metallurgical Plant, accelerated development plan, new phase 3 Katanga Mining Ltd. and La Générale des Carrières et des Mines (Gécamines)	refurbishment and expansion of existing beneficiation plant and refinery	do.	copper-cobalt oxide and sulfide concentrates	8,000 [r, 6]	Cobalt cathode.
2011	Madagascar	Ambatovy Joint Venture Sherritt International Corp., Sumitomo Corp., Korea Resources Corp., SNC-Lavalin Group Inc.	new mine, HPAL processing plant, and refinery	nickel	nickel-cobalt laterite ore	5,600	Cobalt metal powder and briquettes.

See footnotes at end of table.

TABLE 8—Continued
COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2014[1, 2]

Projected year of first production	Country	Project and company[3]	Project type[4]	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2011	Philippines	Coral Bay enhancement Coral Bay Nickel Corp. (Sumitomo Metal Mining Co., Ltd., Mitsui & Co., Ltd., Sojitz Corp., and Rio Tuba Nickel Mining Corp.)	increase capacity of existing operation	nickel	nickel-cobalt laterite ore	1,600 [c, 6]	Nickel-cobalt sulfide.
2011[r]	South Africa	Base Metals Refinery Anglo Platinum Ltd.	expansion of existing refinery	do.	nickel-cobalt-platinum-group metals converter matte	825 [c, 6]	Cobalt sulfate.
2011[r]	United States (Idaho)	Idaho Cobalt Formation Metals Inc. (formerly Formation Capital Corp.)	new mine and refinery	cobalt	stratiform cobalt-copper-gold ore	1,625	Cobalt cathode.
2011	United States (Minnesota)	NorthMet PolyMet Mining Corp.	do.	copper	copper-nickel-platinum-group metals sulfide ore	360	Bulk or separate nickel and copper concentrates initially, followed by nickel-cobalt hydroxide.
2011[r]	Zambia	Muliashi China Nonferrous Metal Mining (Group) Co., Ltd.	new mine and processing plant	do.	copper-cobalt oxide ores	1,500	Cobalt hydroxide.
2011	do.	New Nchanga smelter Konkola Copper Mines Plc	expansion of production from existing smelter	do.	copper-cobalt concentrates	3,000 [6]	Alliage rouge.
2012	Australia	Cloncurry Copper Exco Resources Ltd.	new mine and beneficiation plant	do.	copper-gold-cobalt sulfide ore	NA	Copper concentrate.
2012[5]	do.	Gladstone Nickel, stage I Gladstone Pacific Nickel Ltd.	new mine, beneficiation plant, HPAL processing plant, and refinery	nickel	nickel-cobalt laterite ore	6,000 [r]	Cobalt metal.
2012	do.	Mount Gunson MG 14 deposit Gunson Resources Ltd.	new mine and beneficiation plant	copper	copper-cobalt-silver sulfide ore	215	Copper-cobalt concentrate.
2012[r]	do.	Rocklands Group Copper CuDeco Ltd.	do.	do.	copper-cobalt-gold oxide and sulfide ore	NA	Cobaltic-pyrite concentrate.
2012	Canada	NICO Fortune Minerals Ltd.	new mine, relocated and refurbished beneficiation plant, and refinery	gold	gold-cobalt-bismuth-copper ore	1,800 [12]	Cobalt cathode.
2012[r]	Congo (Kinshasa)	SX-EW plant for cobalt Chemaf SPRL	addition to existing refinery	copper	copper-cobalt ore	6,000 [6]	Do.
2012[r]	Finland	Kevitsa First Quantum Minerals Ltd.	new mine and beneficiation plant	nickel	nickel-copper-cobalt-platinum-group metals-gold sulfide ore	400 [r, e, 12]	Nickel-cobalt-platinum-group metals concentrate.
2012[r]	do.	Outokumpu copper (formerly Kylylahti) Vulcan Resources Ltd.	new mine and refurbished beneficiation plant	copper	copper-zinc-cobalt-nickel-gold sulfide ore	1,200 [r, e, 12]	Nickel-cobalt concentrate.

See footnotes at end of table.

TABLE 8—Continued

COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2014[1, 2]

Projected year of first production	Country	Project and company[3]	Project type[4]	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2012[5]	Finland	Talvivaara Talvivaara Mining Co. Ltd.	expansion of existing operation	nickel	nickel-zinc-copper-cobalt sulfide ore	1,800 [6]	Nickel-cobalt sulfide.
2012[r]	Turkey	Caldag European Nickel PLC and Jiangxi Rare Earth and Rare Metals Tungsten Group Co. Ltd.	mine and heap-leaching operation	do.	nickel-cobalt laterite ore	1,000 [r]	Nickel-cobalt hydroxide.
2013[5]	Australia	Wingellina Nickel Metals X Ltd.	new mine and HPAL processing plant	do.	do.	3,500 [r, 12]	Do.
2013[r]	Cameroon	Nkamouna Geovic Ltd. and Société National d'Investissement du Cameroun	new mine and processing plant	cobalt	do.	4,400 [12]	Cobalt-nickel intermediate.
2013[r, e]	Canada	Nunavik Nickel Canadian Royalties Inc.	new mine and beneficiation plant	nickel	nickel-copper-cobalt-platinum-group metals sulfide ore	425 [12]	Nickel concentrate.
2013	do.	Voisey's Bay Long-Harbour commercial nickel processing plant Vale Inco	new refinery	do.	nickel-copper-cobalt sulfide concentrate	2,500	Cobalt cathode.
2013[r]	Congo (Kinshasa)	Luita Eurasian Natural Resources Corp. PLC	expansion of existing plant	copper	copper-cobalt ore	12,000 [6]	Cobalt carbonate.
2013	do.	WOL/SX/EW refinery, new phase 4 Katanga Mining Ltd. and La Générale des Carrières et des Mines (Gécamines)	new beneficiation plant and SX-EW refinery	do.	copper-cobalt oxide and sulfide ore	12,000	Cobalt hydroxide.
2013[r, e]	Mexico	El Boleo Baja Mining Corp., Korea Resources Corp., L.S. Nikko Copper Inc., Hyundai Hysco Co. Ltd., SK Networks Co. Ltd., and Iljin Copper Foil Co. Ltd.	new mine and refinery	do.	copper-cobalt-zinc-manganese oxide and sulfide ores	2,400 [r]	Cobalt cathode.
2013	Philippines	Mindoro Nickel Intex Resources ASA	new mine, ATML and HPAL processing plant, and refinery	nickel	nickel-cobalt laterite ore	3,300 [r]	Cobalt sulfate.
2013[r]	do.	Taganito Sumitomo Metal Mining Co., Ltd. and Taganito Mining Corp. (Nickel Asia Corp. subsidiary)	new HPAL processing plant	do.	do.	2,600 [r]	Nickel-cobalt sulfide.
2013[r]	United States (Michigan)	Eagle Kennecott Eagle Minerals Co.	new mine, crusher, and rehabilitated beneficiation plant	nickel-copper	nickel-copper sulfide ore	400 [e]	Copper-nickel concentrate.

See footnotes at end of table.

TABLE 8—Continued
COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2014[1, 2]

Projected year of first production	Country	Project and company[3]	Project type[4]	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2014	Canada	Minago Victory Nickel Inc.	new mine and beneficiation plant	nickel	nickel-copper-cobalt-platinum-group metals-precious metals sulfide ore	230 [e, 12]	Nickel concentrate.
2014	Congo (Kinshasa)	Kipoi, stage 2 Congo Minerals sprl and La Générale des Carrières et des Mines (Gécamines),	addition of leaching and SX-EW to existing operation	copper	copper-cobalt oxide ore	800	NA
2014[r, e]	do.	NA La Sino-Congolaise des Mines Sarl (Sicomines) joint venture[13]	new mine(s)	do.	copper-cobalt ore	19,000	NA
2014	do.	Tenke Fungurume, phase 2 Freeport-McMoRan Copper & Gold Inc., Lundin Mining Corp., and La Générale des Carrières et des Mines (Gécamines)	expansion of existing operation	do.	copper-cobalt oxide, mixed oxide/sulfide, and sulfide ores	16,000 [6]	Cobalt hydroxide.
2014[r]	Indonesia	Weda Bay Eramet S.A., Mitsubishi Corp., and PT Antam Tbk	new mine and ATML processing plant	nickel	nickel-cobalt laterite ore	5,000 [r]	Cobalt sulfide.
2014[r]	Philippines	Acoje Rusina Mining NL, European Nickel PLC, and DMCI Mining Corp.	new mine and heap-leaching operation	do.	do.	930 [12]	Nickel-cobalt hydroxide.

[e] Estimated. [r] Revised. Do., do. Ditto. NA Not available.

[1] Estimated data are rounded to no more than three significant digits.

[2] Projects in feasibility or later stages of development in 2009. Actual startup dates may be postponed owing to economic or other factors. Additional projects might produce cobalt by 2014, but not enough information was available to include them.

[3] SX-EW solvent extraction—electrowinning.

[4] ATML Atmospheric leach. HPAL High pressure acid leach. WOL Whole ore leach.

[5] Startup date provided before project postponement was announced; no information is available on the length of delay.

[6] Total capacity following expansion.

[7] Project remained on care-and-maintenance status as of June 15, 2010.

[8] SX-EW line will not increase total plant capacity.

[9] On December 19, 2008, Goro was renamed Vale Inco Nouvelle-Calédonie.

[10] Project scope under evaluation, may process ore or cobalt sulfide tailings offshore.

[11] Construction suspended in September 2009 following cancellation of exploitation permit; First Quantum has commenced international arbitration on the matter.

[12] Average production.

[13] The Sicomines joint venture comprises the following Chinese and Congolese companies, listed in order of share ownership: China Railway Construction Corp. Ltd., La Générale des Carrières et des Mines (Gécamines), China Metallurgical Group Corp., Sinohydro Corp., and La Société Immobilière du Congo (Congo Simco).

TABLE 9

COBALT: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, cobalt content)

Country[3]	2005	2006	2007	2008	2009[e]
Australia[4]	4,590 [r]	5,130 [r]	4,730 [r]	4,780 [r]	4,630 [5]
Botswana[6]	326	303	242	337	335
Brazil[e]	1,400	1,100	1,311 [r, 5]	1,215 [r, 5]	1,200
Canada[7]	5,767	7,115	8,692	8,953 [r]	4,072 [p, 5]
China[e]	2,100	1,840	6,100	6,630 [r]	6,000
Congo (Kinshasa)[e, 8]	24,500	27,100	25,400 [r]	32,300 [r]	35,500
Cuba[9]	4,798	5,602	4,540	3,175	3,500
Finland[e]	100	100	115	105 [5]	27
Indonesia[10]	1,600	1,600	1,600	1,300	1,200
Morocco[e, 11]	1,600	1,500	1,600	1,700	1,600
New Caledonia[12]	1,769	1,629	1,620	869 [r]	1,000
Philippines[e]	300	900	1,000	1,200 [r]	1,500
Russia[e, 11]	6,300	6,300	6,300	6,200	6,100
South Africa[e]	620	600	600	590	610
Zambia[e, 13]	9,300	8,000	7,500	6,900	5,000
Zimbabwe[e, 14]	100	110	100	85	74 [5]
Total	65,200 [r]	68,900 [r]	71,500 [r]	76,300 [r]	72,300

[e]Estimated. [r]Revised.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 11, 2010. Figures represent recoverable cobalt content of ores, concentrates, or intermediate products from cobalt, copper, nickel, platinum, or zinc operations.

[3] In addition to the countries listed, Poland, Spain, and Turkey are known to produce ores that contain cobalt, but information is inadequate to make reliable estimates of production. Other copper-, nickel-, platinum-, or zinc-producing nations may also produce ores containing cobalt as a byproduct component, but recovery is small or nil.

[4] Cobalt produced from lateritic and sulfide ores by the Western Australian nickel industry as reported by the State government. Quantities of cobalt contained in intermediate or refined metallurgical products produced from Australian and imported ores, in metric tons, was estimated to be as follows: 2005—4,900; 2006–07—5,500; 2008—5,100; and 2009—5,500.

[5] Reported figure.

[6] Reported cobalt content of pelletized nickel-copper matte.

[7] Assay content of cobalt in concentrates produced.

[8] Cobalt content of concentrates, tailings, and slags.

[9] Determined from reported nickel-cobalt content of sulfide and ammoniacal liquor production.

[10] Cobalt content of nickel matte plus estimated cobalt in lateritic ore processed in Australia.

[11] Cobalt content of concentrates.

[12] Cobalt content of limonitic nickel laterite ores mined. Quantities of cobalt contained in intermediate or refined metallurgical products (cobalt chloride and cobalt oxide hydroxide) produced from New Caledonian ores exported to Australia and France, in metric tons, was estimated to be as follows: 2005–06—1,200; 2007—1,400; 2008—1,200; and 2009—1,500.

[13] Cobalt content of concentrates and slags.

[14] Estimated cobalt content of intermediate products produced in Zimbabwe from nickel and platinum ores mined in Zimbabwe.

TABLE 10

COBALT: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, cobalt content)

Country[3]	2005	2006	2007	2008	2009
Australia, metal powder and oxide hydroxide[e]	3,150	3,700	3,680	3,620	4,050
Belgium, metal powder, oxide, hydroxide[4]	3,298	2,840	2,825	3,020	2,150
Brazil, metal	1,136	902	1,148	994	1,012
Canada, metal, metal powder, oxide	5,090	5,198	5,620	5,637 [r]	4,918 [p]
China, metal, metal powder, oxide, salts[e, 5]	12,700	12,700	13,200	18,200	23,100
Congo (Kinshasa), metal[6]	600	550	606	1,049 [r]	2,950
Finland, metal powder and salts[7]	8,171	8,582	9,173	9,645	8,962
France, chloride	280	256	305	311	368
India, metal and salts	1,220	1,184	980	858	1,001
Japan, metal	471	920	1,084	1,071	1,332
Morocco, metal and oxide	1,613	1,405	1,591	1,711	1,600
Norway, metal	5,021	4,927	3,939	3,719	3,510
Russia, unspecified[e, 8]	5,000	5,000	3,800	2,500	2,352
South Africa, metal powder and sulfate	268	267	307	244	238
Uganda, metal	638	674	698	663	673
Zambia, metal	5,422	4,665	4,335	3,991	1,535
Total	54,100	53,800	53,300	57,200 [r]	59,800

[e] Estimated. [r] Revised.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 11, 2010. Figures represent cobalt refined from ores, concentrates, or intermediate products and do not include production of downstream products from refined cobalt.

[3] In addition to the countries listed, Germany and Poland may produce some cobalt, but information is inadequate to make reliable estimates of production.

[4] Production reported by n.v. Umicore s.a.; includes production from China and South Africa that is not otherwise included in this table.

[5] Production from domestic and imported ores and concentrates; excludes production by n.v. Umicore s.a. that is included under Belgium.

[6] Excludes production of cobalt in white alloy, matte, and slag that would require further refining.

[7] Production for 2005–08 reported by the Geological Survey of Finland; production for 2009 reported by OM Group Inc.

[8] Production reportedly includes metal, oxide, and salts; other forms may also have been produced.

COPPER

By Daniel L. Edelstein

Domestic survey data and tables were prepared by Samir Hakim, statistical assistant, and the world production tables were prepared by Glenn J. Wallace, international data coordinator.

In the United States, mine production of recoverable copper in 2009 declined by about 130,000 metric tons (t) to 1.18 million metric tons (Mt), and was slightly above the production level in 2007. Most of the production decline took place in Arizona and New Mexico, following the collapse of copper prices during the fourth quarter of 2008.

Despite numerous announced expansions in global mine capacity that totaled about 750,000 t, lower capacity utilization, particularly in the United States, resulted in a global copper mine production increase of only about 420,000 t compared with that in 2008. In addition to lower copper prices, numerous factors, including labor unrest, lower ore grades, technical problems, and utility and equipment shortages, continued to plague the industry and sustain a downward trend in capacity utilization.

The United States was the third leading mine producer of copper, though its share of global production decreased to 7% from 8% in 2008. In 2008, the United States had regained its position as the second leading producer of copper from Peru, only to relinquish it again in 2009. Chile remained the leading world mined copper producer, and accounted for 34% of global production. Global smelter production, which had risen steadily since 2003, declined nominally in 2009 owing to a global tight supply of concentrates and scrap. Global refinery production, however, rose slightly. The United States rose to sixth place ahead of Germany in world smelter production and remained fourth in refinery output behind China, Chile, and Japan.

According to data compiled by the International Copper Study Group (ICSG) (2010a, p. 19–20), global consumption of refined copper, which had fallen by about 185,000 t (1%) in 2008, rose nominally (130,000 t) in 2009 and remained slightly below that in 2007. Consumption declines in Europe, North America, and most major consuming regions of Asia were more than offset by an astronomical growth of almost 2 Mt (38%) in China's apparent consumption. The only other major consumer to experience growth was the Republic of Korea, where consumption rose by 120,000 t (16%).

For the second year in a row, global production of refined copper slightly exceeded demand, and reported yearend global inventories of refined copper rose by about 270,000 t in 2009 and 400,000 t during a 2-year period. Although global stocks rose to 1.43 Mt at yearend 2009 (about 4 weeks of global consumption) inventories in the second and third quarters of 2009 were at or below yearend 2008 levels, principally owing to strong imports by China (International Copper Study Group, 2010a, p. 9). Copper prices, which tumbled during the fourth quarter of 2008 following the onset of the economic crises (the average COMEX price fell from a record-high $3.76 per pound of copper in July to $1.39 per pound in December), trended upward throughout 2009, with the COMEX price averaging $3.19 per pound in December and $2.35 for the full year.

The principal mining States for copper were, in descending order of production, Arizona, Utah, New Mexico, Nevada, and Montana, accounting for 99% of domestic production; copper was also recovered at mines in Idaho and Missouri. Although copper was recovered at 29 mines in the United States, 18 mines accounted for more than 99% of production (table 2). The remaining mines were either small leach operations or byproduct producers of copper.

In 2009, copper recovered from refined or remelted scrap (about 80% from new scrap and 20% from old scrap) composed 35% of the total U.S. copper supply. The conversion of old scrap to alloys and refined copper fell by 12% to 137,000 t of recoverable copper. Copper was consumed as refined copper and as direct melt scrap at about 30 brass mills, 15 wire-rod mills, and 500 chemical plants, foundries, and miscellaneous operations.

Legislation and Government Programs

In June, the U.S. Environmental Protection Agency (EPA) issued final rules governing emissions from nonferrous foundries, including copper and copper-based alloy foundries that melt at least 600 t/yr of metal and use metal containing hazardous air pollutants (HAP). The HAP listed for copper foundries are lead or nickel in amounts greater than or equal to 0.1% by weight, and manganese in amounts greater than or equal to 1.0% by weight. The final standards, which mandated that new operations be in compliance by June 25, 2009, or upon startup, and existing operations be in compliance by June 27, 2011, require that the foundries cover or enclose melting furnaces that are equipped with covers or enclosures to the extent practicable and to purchase only scrap material that has been depleted to the extent practicable of HAP material, excluding HAP metals that are required to be added for the production of specific alloyed castings. In addition, existing and new large foundries that melt at least 6,000 metric tons per year (t/yr) of copper were required to control emissions of particulate matter by 95% [or an outlet concentration not exceeding 0.015 grain per dry standard cubic foot (gr/dscf)] and 99% (or an outlet concentration of 0.010 gr/dscf) (U.S. Environmental Protection Agency, 2009).

In September, four domestic producers of copper tube requested the imposition of antidumping duties on seamless refined-copper pipe and tube imported from China and Mexico. On October 27, the Import Administration, International Trade Administration, U.S. Department of Commerce, found that the petition had sufficient documentation and industry support to warrant the initiation of antidumping duty investigations.

The petitioners alleged that these imports were, or were likely to be, sold in the United States at less than their fair value and that such imports were materially injuring or threatening material injury to the U.S. tube industry. The investigation was continuing at yearend (U.S. Department of Commerce, 2009).

The U.S. Department of Labor Employment and Training Administration (ETA) received numerous applications for Trade Adjustment Assistance from workers who claimed that imports of copper and copper products and a shift in production to a foreign source resulted in their job loss. In June, after reconsideration of a previous negative determination, the ETA certified employees of Cerro Flow Products Inc. (Sauget, IL) who became totally or partially separated during a 2-year period beginning November 4, 2008, to receive alternate trade adjustment assistance under section 246 of the Trade Act of 1974. In separate determinations, workers from Freeport-McMoRan Tyrone LLC (Tyrone, NM) and BHP Copper Inc., Pinto Valley Operations & San Manuel Arizona Railroad Co., and BHP Billiton Ltd. (Miami, AZ) received certification to apply for trade adjustment assistance (U.S. Department of Labor, 2009a–c).

Production

Domestic mine production decreased by about 10%, or about 130,000 t, owing to closures and cutbacks announced during the fourth quarter of 2008 in response to the onset of a global recession and the plummet in copper prices. Estimated mine capacity, however, rose by about 50,000 t to 1.72 Mt owing to the startup of one operation and full-year operations at expansions begun in 2008. Capacity utilization declined to 69% from 78% in 2008 and was at its lowest level in more than 25 years. Smelter production, however, rose by about 5% owing to increased smelter availability (maintenance closures having reduced output in 2008) and lower concentrate exports. Downstream, electrolytic refined production declined by 11% owing to a shortage of anode resulting from lower net imports. Electrowon copper from leach solutions accounted for 40% and 41%, respectively, of mine and refinery production. Four primary electrolytic refineries and 15 solvent extraction-electrowinning (SX-EW) facilities operated during 2009.

Company Reviews.—Consolidated full-year production for ASARCO LLC's mines in 2009 totaled 186,000 t. The company continued to operate under Chapter 11 reorganization protection through most of 2009 and the tug-of-war between Grupo México S.A.B. de C.V. (Mexico City, Mexico) and Sterlite Industries (India) Ltd. [a subsidiary of Vedanta Resources plc (London, United Kingdom)] to gain control of Asarco continued. ASARCO Incorporated had filed for bankruptcy protection in 2005 and had been operating as ASARCO LLC. In March 2009, Asarco announced the signing of a new agreement to sell substantially all of its operating assets to Sterlite for $1.1 billion in cash plus a promissory note for $600 million, payable during 9 years. In November, however, the U.S. District Court judge overseeing the bankruptcy reorganization issued an order confirming a competing reorganization plan sponsored by Americas Mining Corp., a subsidiary of Grupo México. On December 9, Grupo México announced that the Chapter 11 restructuring of ASARCO LLC had been completed and that full control of Asarco had been returned to Grupo México. A combined $3.63 billion payment was made to Asarco's creditors ($720 million Grupo México contribution, $1.5 billion secured financing, and $1.41 billion available cash from Asarco) and a $280 million promissory note delivered to asbestos creditors. Under terms of the restructuring, these payments rendered Asarco free of environmental contingencies and liabilities from past Asarco operations (ASARCO LLC, 2009a, b; Grupo México, S.A.B. de C.V., 2009; 2010a, p. 6; 2010b, p. 9).

Augusta Resource Corp. (Vancouver, British Columbia, Canada) was proceeding with development of the Rosemont Mine, about 50 kilometers (km) southeast of Tucson, AZ. In January, the company completed an updated bankable feasibility study for an open pit copper operation. An updated mineral reserve estimate completed in November 2008 indicated proven and probable reserves of 546 Mt of sulfide ore grading 0.45% copper and 0.015% molybdenum and 70 Mt of oxide ore grading 0.17% copper. Augusta Resource anticipated building a 68,000 metric-ton-per day (t/d) mill for sulfide ore and a heap-leach SX-EW facility with a combined production of 100,000 t/yr of copper. In March, the company received notification from Arizona that its mined land reclamation plan had been approved. In July 2009, Augusta Resource signed an agreement to purchase 23 haulage trucks for an estimated $82.2 million. By yearend, the target dates for startup of leach and concentrate production had slipped by about 6 months to the first and third quarters of 2012, respectively (Augusta Resource Corp., 2010, p. 2–5).

Copper production from BHP Billiton's (Melbourne, Australia, and London, United Kingdom) residual Arizona leach operations at Miami and Pinto Valley continued to decline, the combined production falling to 6,000 t in 2009 from 6,700 t in 2008. Production of copper concentrate at Pinto Valley, which was resumed in October 2007 to "take advantage of market conditions at the time," yielded 4,400 t of payable copper in concentrates, production having been suspended during February owing to the sharp drop in copper prices and the relatively high cost and anticipated short life of the operation (BHP Billiton, 2009, p. 3, 8; 2010, p. 2).

Resolution Copper Mining, LLC [55% Rio Tinto plc (London) and 45% BHP Billiton] continued with development work and resource definition of the Resolution copper sulfide deposit located more than 2,100 meters (m) below the surface and beneath BHP Billiton's shuttered Magma Mine, with the goal of commencing production by 2020. By the end of October, Resolution had completed 530 m of a proposed 2,100 m mineshaft and by yearend, had completed a new headframe. Construction of a water treatment plant and 43-km pipeline to deliver treated water to district farmers for irrigation was completed and the anticipated 2-year dewatering of the old # 9 shaft begun. Resolution was seeking a land exchange required to access to about 3,100 hectares of Federally controlled property, and during 2009, legislation was introduced in both houses of the U.S. Congress to facilitate the exchange. By February 2009, $290 million had been invested in the project (Resolution Copper Mining, LLC, 2009, p. 6–7).

Constellation Copper Corp.'s (Denver, CO) Lisbon Valley Mine in Utah, which began production in November 2006, continued limited electrowon production from the residual leaching of stockpiled ore. Mining ceased during the first quarter of 2008, and in December 2008, Constellation filed for assignment in bankruptcy under Canada's Bankruptcy and Insolvency Act (Deloitte & Touche Inc., 2009, p. 1–6).

Mercator Minerals Ltd. (Kingman, AZ, and Vancouver) began commercial production and shipment of copper and molybdenum concentrates at the Mineral Park Mine (Arizona) from its Phase I, 23,000-t/d mill. For 2009, mill throughput averaged 18,200 t/d of ore grading 0.21% copper and 0.023% molybdenum. Average copper and molybdenum recovery was 73% and 48.5%, respectively, significantly less than the respective design recoveries of 80.2% and 75.6%. Production of copper in concentrate was 11,400 t, and production of electrowon copper cathode was 2,000 t, which was down significantly from production of 4,800 t of electrowon copper in 2008. Yearend mill reserves totaled 428 Mt containing 549,000 t of copper, and leach reserves totaled 71 Mt grading 0.07% copper (Mercator Minerals Ltd., 2010, p. 17, 22).

In 2009, Mines Management, Inc. (Spokane, WA) spent $7.4 million on development, including rehabilitation work on its evaluation adit, at its Montanore silver-copper project in northwestern Montana. The project hosts one of the world's largest known silver-copper deposits, with estimated resources containing more than 7 million kilograms of silver and nearly 900,000 t of copper. In April, Mines Management released its draft environmental impact statement for public comment through June 29. The project had already undergone extensive engineering and was designed with an initial production capacity of approximately 12,500 t/d of ore and an estimated annual production of about 250,000 kilograms of silver and 27,000 t of copper (Mines Management, Inc., 2010, p. 1–10).

In January 2008, Nord Resources Corp. (Dragoon, AZ) reported the first production of cathode since August 2003 from the leaching of stockpiles at its Johnson Camp Mine in Arizona. In February 2009, it resumed mining and in April reported its first cathode production from newly mined ore. Production rose to 3,700 t in 2009 from 1,300 t in 2008 but remained well below its target production of 11,300 t/yr owing to lower than expected copper recoveries, a well failure, and a fourth quarter drought that reduced flow rates of pregnant leach solution. In January 2010, two new wells were commissioned (Nord Resources Corp., 2010).

The past-producing Zonia Mine (Arizona) continued to change ownership when Redstone Resources Corp. (Lakewood, CO) acquired Zonia from Copper Mesa Mining Corp. (formerly Ascendant Copper Corp.), a Canadian mineral exploration and development company, that had acquired it from St. Geneviève Resources Ltd. (Montreal, Quebec, Canada) in 2008. Redstone was proceeding with five development programs aimed at generating a final feasibility study. A preliminary economic analysis completed in December determined a measured and indicated resource of 30.2 Mt grading 0.36% copper at a 0.2% cutoff grade. Before it suspended activity in November 2008, Copper Mesa had anticipated constructing an open pit mine and SX-EW processing complex that could produce an average of 9,000 t/yr of copper cathode (Copper Mesa Mining Corp., 2009, p. 1–3; Redstone Resources Corp., 2010a, b).

In July 2008, Freeport-McMoRan Copper & Gold Inc. (FCX) announced that it had initiated plans for incremental expansions at its Bagdad, Morenci, and Sierrita Mines in Arizona, and its Cerro Verde Mine in Peru, and that it had restarted mining at its Miami Mine and expected to produce 45,000 t/yr of cathode by 2010. In December 2008, however, in response to the decline in copper and molybdenum prices, FCX reversed course and announced revised production plans that included a 25% reduction in the mining and crushed-leach rates at its Morenci Mine, a 50% reduction in the mining and stacking rates at its newly commissioned Safford Mine in Arizona, a 50% reduction of its mining rate at its Tyrone Mine in New Mexico, and suspension of mining and milling activities at the Chino Mine in New Mexico. In January 2009, FCX announced an additional 25% reduction in Morenci's mining and crushed-leach rates. As a result of these and other changes, copper production from FCX U.S. operations decreased to 555,000 t from 699,000 t in 2008 (Freeport-McMoRan Copper & Gold Inc., 2008a, b, p. 9; 2010a, p. 30–31, 2010b, p. 7, 23).

Production of recoverable copper at the Morenci Mine complex decreased to 229,000 t from 334,000 t in 2008. Though the distribution between electrowon copper and copper-in-concentrate were not reported, nearly all production was electrowon. According to the revised mine plan, the mill and concentrate-leach project were closed during the first quarter of 2009 (Freeport-McMoRan Copper & Gold Inc., 2010b, p. 8, 23).

Production of 102,000 t of recoverable copper (concentrate and electrowon) at FCX's Bagdad Mine in Arizona was essentially unchanged from that in 2008. The Bagdad operation consists of a 75,000-t/yr concentrator and an 11,000-t/yr SX-EW plant that operated near full capacity throughout 2009 (Freeport-McMoRan Copper & Gold Inc., 2010b, p. 10, 23).

At the Sierrita copper-molybdenum mine, copper production decreased to 77,000 t of recoverable copper from 85,000 t in 2008. An 18,000-t/yr copper sulfate plant started in early 2004 continued to operate below capacity. The Sierrita operation includes a 93,000-t/d concentrator and the Twin Buttes elecrowinning facility, with a design capacity of about 23,000 t/yr of cathode. In December, FCX purchased property adjacent to Sierrita, including the Twin Buttes Mine, which last produced in 1994 (Freeport-McMoRan Copper & Gold Inc., 2010b, p. 9, 23).

Despite initial plans to resume mining, the Miami open pit remained on care-and-maintenance status, and electrowon production from residual leach operations declined to 7,300 t from 8,600 t in 2008. In the fourth quarter, FCX initiated plans to restart limited mining at Miami. FCX anticipated that production would ramp up to about 45,000 t/yr of cathode by the second half of 2011 for an expected 5-year mine life. At yearend, the mine leach reserves were 227,000 t of recoverable copper (Freeport-McMoRan Copper & Gold Inc., 2010b, p. 11, 23, 32).

The Safford Mine, which started up during the first quarter of 2008, produced 83,500 t of electrowon copper, up from 60,000 t in 2008, but below its capacity of 109,000 t/yr, a reflection of the cutback that reduced the mining and stacking rate by 50% in late 2008. Mined ore passed through a three-stage crushing and agglomeration process before being transferred to leach pads via a mobile conveying system (Freeport-McMoRan Copper & Gold Inc., 2010b, p. 10).

In New Mexico, production at FCX's Chino Mine plummeted to 16,300 t of electrowon copper from 70,300 t (electrowon and concentrates) following cessation of mining at yearend 2008. Production at the Tyrone Mine rose to 39,000 t from 34,500 t in 2008 and was at its highest level since 2004, despite the 50% reduction mining rate starting in late 2008. The mining rate was restored to 80% of capacity by early 2010. The available mining fleet had the capacity to move 120,000 t/d of material, and the SX-EW operation had a capacity to produce 76,000 t/yr of cathode (Freeport-McMoRan Copper & Gold Inc., 2010b, p. 12, 23).

Formation Metals Inc. (formerly Formation Capital Corp.) (Vancouver) was proceeding with its development of the underground Idaho Cobalt Project that was projected to produce about 2,000 t/yr of copper as a byproduct of cobalt production. The company received a bankable feasibility study in July 2007, a final environmental impact statement in June 2008, and a series of permits and decisions during the first half of 2009. Construction, which began in early 2010, was expected to take 1 year to complete. Proven and probable reserves were reported to be 2.64 Mt grading 0.56% cobalt and 0.6% copper (Formation Metals Inc., 2010).

The Pebble Limited Partnership, an equal partnership between Anglo American plc (London) and Northern Dynasty Minerals Ltd. (Vancouver), allocated more than $69 million for advancement of the project in southwest Alaska during 2009, bringing the total project investment through 2009 to about $430 million. In February 2010, an updated mineral resource assessment based on additional drilling was released. The assessment increased estimates of contained copper, gold, and molybdenum by 12%, 14%, and 16%, respectively, from the December 2008 estimates. At a copper equivalent cutoff grade of 0.3% copper, the updated measured and indicated resources totaled 5.94 billion metric tons (Gt) grading 0.42% copper (0.78% copper equivalent) and containing 25 Mt of copper; the updated inferred mineral resource totaled 4.84 Gt grading 0.24% copper (0.53% copper equivalent) and containing 11.6 Mt of copper (Northern Dynasty Minerals Ltd., 2009, 2010).

PolyMet Mining Corp. (Vancouver) was proceeding with the development of the NorthMet copper-nickel-precious metals project (mine and processing plant) in northeastern Minnesota. In May 2008, the company announced revised plans and cost estimates that would shorten the preproduction construction period to less than 12 months and improve cash flow by initially selling concentrate. The estimated $290 million construction cost for the metallurgical plant to process the concentrate would be funded through the sale of concentrate. In October, Polymet announced completion of a "strategic partnership" with Glencore International AG (Baar, Switzerland) under which Glencore would purchase Polymet's output of concentrates, metals, or intermediate products at prevailing market terms for at least the first 5 years of production prior to construction of its metallurgical facilities. It also provided Glencore with options to purchase an equity stake in Polymet. At mid-2009, engineering of the project, other than that required for permitting, was slowed in response to the weak copper market, though in November, Polymet published the draft environmental impact statement (Polymet Mining Corp., 2010, p. 110).

Quadra Mining Ltd. (Vancouver) reported that copper in concentrate production at its Robinson Mine in Nevada decreased to 55,600 t from 72,400 t in 2008. Changes in the mine plan for its Veteran Pit required by the U.S. Mine Safety and Health Administration and variable metallurgical performance from ore mined in the Wedge area of the Ruth Pit accounted for the lower output. As a result, average ore grade fell to 0.64% copper from 0.68% in 2008, mill recoveries fell to 63.6% from 76.7%, byproduct gold production declined by 28%, and cash production costs rose to $1.25 per pound of copper from $1.15 per pound in 2008. At its Carlota Mine in Nevada, which produced its first cathode in December 2008, production of electrowon copper rose to 12,700 t from 360 t in 2008 but was lower than anticipated owing to diversion of mining equipment to unplanned development work (Quadra Mining Ltd., 2010, p. 7–8).

In 2009, the Bingham Canyon Mine in Utah regained its position, last held in 1983, as the leading U.S. copper mine producer. Rio Tinto reported that mill throughput at Bingham Canyon reached a record-high level in 2009 and that copper contained in concentrates rose to a record-high 303,500 t, an increase of 28% from that of 2008. Production of refined copper rose to 274,000 t from 201,000 t in 2008. Yearend reserves at Bingham Canyon were expected to be sufficient to sustain open pit mining through 2020, with additional resources that could extend pit life through 2032. A prefeasibility study was expected to be completed in 2010 that would potentially allow conversion of these additional resources to reserves. In March, Rio Tinto disclosed the discovery of a new molybdenum deposit (copper-molybdenum-gold porphyry system) beneath the current open pit that contained between 450 and 550 Mt of material grading 0.15% molybdenum (Rio Tinto plc, 2010, p. 38, 64).

In December 2008, Rio Tinto announced plans to invest $300 million to develop the Eagle nickel-copper mine near Marquette, MI. By yearend 2009, Eagle had received final approval of all necessary State permits and was nearing readiness to begin construction. The mine was expected to yield 16,000 t/yr of nickel and 15,000 t/yr of copper during at least a 7-year period from a resource grading 3.6% nickel and 2.9% copper (Rio Tinto plc, 2009, p. 56; 2010, p. 39).

Consumption

U.S. reported consumption of refined copper declined by about 18% to the lowest level since the recession of 1975. Consumption fell off sharply during the fourth quarter of 2008 following the onset of the economic crisis and remained low throughout 2009. Consumption by wire-rod producers declined by about 350,000 t (23%) in response to depressed housing demand and would have fallen further had it not been for a 35,000-t decline (90,000-t 2-year decline) in net imports of wire rod. According to data compiled by the American Bureau of Metal Statistics, Inc. (ABMS) (2010b) apparent consumption of wire rod declined for the fourth consecutive year and was down by about 365,000 t (25%) from that in 2008. In the first quarter of 2009, Asarco announced a reduction in output at its Amarillo plant. Superior Essex Inc., which had closed its Vincennes, IN, wire-rod mill in 2008, operated only one of the two lines at its plant in Arcola, IN, during 2009.

According to ABMS, domestic shipments of copper and copper alloy mill products declined by 26% from shipments in 2008 and fell below 1 million short tons (907,000 metric tons) for the first time since 1962. Year-on-year shipments were down by more than 30% during the first half of the year but were down by only about 10% during the fourth quarter. Shipments were down in all market segments—copper and copper alloy strip and sheet fell by 38% and 20%, respectively; copper and copper alloy rod and bar fell by 21% and 31%, respectively; and copper and copper alloy tube fell by 22% and 23%, respectively. Copper tube, which represented one-third of all brass mill product shipments, fell for the fourth consecutive year. This was indicative of the poor housing construction market and the continued substitution by plastic tube in residential markets (American Bureau of Metal Statistics, Inc., 2010a, p. 14–16).

According to preliminary data from the Copper Development Association Inc. (2010, p. 18–21), the total supply of copper and copper alloy products to the U.S. market by fabricators (brass mills, foundries, powder producers and wire mills), which included net imports, declined by about 23% in 2009 from the revised shipments for 2008 and was down by more than 50% from its peak in 2000. Wire-mill products accounted for about 51% of total shipments to the domestic market; brass mill products, 45%; and foundry and powder products, 4%. Consumption in the building construction sector, which remained the largest end-use market, declined by 25% and accounted for about 49% of shipments. The electric and electronic products (20% market share), transportation equipment (12% market share), consumer and general products (10% market share), and industrial machinery and equipment (9% market share) sectors declined by 25%, 13%, 26%, and 15%, respectively.

Prices and Stocks

Copper prices which tumbled during the fourth quarter of 2008 in response to the onset of the economic crisis (the monthly COMEX price average fell from a record high $3.76 per pound of copper in July to $1.39 per pound in December) trended upward throughout 2009 with the COMEX price averaging $3.19 per pound in December and $2.35 for the full year. The London Metal Exchange Ltd. (LME) and U.S. producer's price trends closely tracked that of the COMEX price, averaging $2.34 per pound and $2.41 per pound, respectively, for 2009.

For the second year in a row, global production of refined copper slightly exceeded demand, and reported yearend global inventories of refined copper rose by about 270,000 t in 2009 and 400,000 t during the 2-year period. Although global stocks rose from a minimum of 870,000 t in 2005, to 1.43 Mt at yearend 2009, they remained below their peak level of more than 2 Mt in 2002. Stocks at yearend 2009 represented about 4 weeks of global supply compared with about 3 weeks at yearend 2008 and 7 weeks in 2002 (International Copper Study Group, 2010a, p. 9).

Although first quarter 2009 and yearend inventories were up compared with those at yearend 2008, inventories in the second and third quarters of 2009 were at or below yearend 2008 levels. High import levels by China resulted in a relatively tight market through much of the year and encouraged the upward trend in copper prices. Chinese imports during the second quarter of 2009 totaled more than 1 Mt, and full-year imports rose by 112% to 3.18 Mt (International Copper Study Group, 2010a, p. 29).

Commodity exchange inventories [COMEX, LME, and Shanghai Futures Exchange (SHFE)] finished 2009 at about 688,000 t, 76% higher than yearend 2008 inventories. COMEX and LME inventories held in the United States rose to 373,000 t from 137,000 t at yearend 2008.

Copper scrap prices generally followed the trend in refined copper prices. With higher refined prices, however, the discount of most grades of copper scrap to refined copper increased. According to American Metal Market price data, the discount for refiners' No. 2 scrap from the COMEX price averaged 29.6 cents per pound for the year, below the average discount of 34.4 cents per pound in 2008, and ranged between 13.4 cents per pound in May and 47.2 cents per pound in December. Lower refined copper prices and high export demand, converged to narrow the discount during the second quarter of 2009. Though following the same trend, the discount for No. 1 brass mill scrap remained much smaller, averaging 8.6 cents per pound for the year, and ranging between 3.9 cents per pound in May to 14.1 cents per pound in December.

Foreign Trade

In response to weak demand, net refined copper imports in 2009 declined for the third consecutive year, falling by about 15% to 583,000 t, and were at their lowest level since 1998. Chile, Canada, and Peru were the leading sources of refined copper in 2009, accounting for 47%, 28%, and 19%, respectively of refined imports. From 2006 through 2009, Chile was the leading source of unwrought copper products (41%), followed by Canada (33%), and Peru (13%). Refined copper accounted for 82% of unwrought copper imports during the same period. Exports of copper contained in concentrates declined by 50% to 151,000 t owing to reduced mine production from nonintegrated producers and to increased smelter operating rates at integrated producers (maintenance shutdowns had reduced smelter output in 2008).

According to U.S. Census Bureau data compiled by the Copper and Brass Fabricators Council Inc. (2010, p. 1–9), in 2009, U.S. imports of copper and copper-alloy semifabricated products (excluding wire-rod mill products) were 194,000 t (down by 30% from those in 2008), exports were 98,000 t (down by 27%), and the resulting net imports declined by 33% to 95,600 t. Canada and Mexico collectively accounted for 66% of semifabricated copper exports and 27% of imports. China, with a 26% share, was the leading source of imports but was the destination for less than 9% of exports.

ABMS adjusted trade data indicate that the United States had only nominal net imports of copper wire rod in 2007, down from 35,000 t in 2008. Imports fell to 113,000 t from 156,000 t in 2008, and exports declined to 112,000 t from 121,000 t in 2008. The decline in net imports of wire rod, which have trended downward from a record peak of 221,000 t in 2005, have somewhat moderated the decline in U.S. consumption of refined copper. Canada remained the leading source of wire-rod imports (75%), followed by Russia (16%), and Mexico (7%). Mexico, (72%) and Canada (27%) were the recipients of nearly all wire-rod exports (American Bureau of Metal Statistics, Inc., 2010b).

Exports of copper and copper alloy scrap of 842,000 t were down by 66,000 t from those in 2008. China (including Hong Kong) was the destination for 78% of domestic scrap exports and, based on import data, accounted for 68% of reported global scrap trade of 6.2 Mt (International Copper Study Group, 2010a, p. 39–42).

World Review

World production of refined copper rose by about 90,000 t, less than 1%, in 2009 as increases in electrowon and secondary refined production were countered with reduced primary electrolytic copper production. World copper use, according to revised ICSG data, rose slightly in 2009 to about 18.2 Mt but remained slightly below the record high use in 2007. Consequently, the global market balance indicated a small production surplus of about 167,000 t in 2009, up slightly from 144,000 t in 2008. The 2-year surplus of about 300,000 t was essentially equal to the revised deficit for 2007. Stocks held on the more visible commodity exchanges rose by about 300,000 t to 688,000 t, and were at their highest level in 5 years. ICSG estimates of total reported inventories (exchanges, governments, and industry) rose by about 270,000 t to 1.43 Mt. Note that with the exception of exchange inventories, inventory levels in China were not reported and were discounted in these analyses. Consumption data for China are based on apparent consumption of refined copper (production, net trade, and SHFE stock changes) and did not account for changes in industry and government stock levels (International Copper Study Group, 2010a, p. 9–20).

World mine production of copper rose by about 420,000 t, about 3% compared with that of 2008, to a record-high 15.9 Mt. World copper mine production had remained relatively flat from 2005 to 2008, increasing by about 3% during the period. This low level of growth took place despite an estimated 11% capacity growth from 2005 to 2008, according to data compiled by the ICSG. Consequently, capacity utilization at global copper mines fell from 88.9% in 2005 to 83.1% in 2008. With global mine capacity increasing by about an additional 4% in 2009, capacity utilization fell to about 81.6% in 2009. Numerous factors contributed to the downward trend, including competition for labor, power, and equipment from a global boom in mineral commodity production; labor unrest; preferential mining of coproducts; political uncertainty; and technical problems associated with aging and expanding operations. In 2009, the sharp fall in prices during the fourth quarter of 2008 led to industry curtailments and delays or deferrals of anticipated projects (International Copper Study Group, 2010c, p. 13).

Production of copper in concentrates, which rose by about 260,000 t to 12.6 Mt, was insufficient to meet growing smelter demand, and concentrate supplies remained tight through most of 2009. Smelter production capacity increased by 700,000 t in 2009 and 2.3 Mt from the 2005 to 2009 period, while production of copper in concentrate increased by only about 300,000 t during the same period (International Copper Study Group, 2010c, p. 14). According to CRU International Ltd. (2010a, p. 67–72), consumption of copper in concentrates exceeded supply by about 180,000 t and fell far short of global demand as smelter capacity utilization fell to 69.5% from 72.2% in 2008. According to CRU, the cumulative 3-year deficit was about 450,000 t of copper in concentrate. The combined spot treatment (smelting) and refining charge (TC/RC), which had fallen to about 3 cents per pound during the third quarter of 2008, spiked back above 20 cents per pound in December 2008 and January 2009 following the onset of the economic crisis and announced smelter cutbacks. With renewed buying by Chinese smelters, the combined TC/RC fell sharply throughout 2009 and reportedly was back at the 3-cent-per-pound level during the fourth quarter of 2009. Spot TC/RCs have trended lower since 2005, when they averaged about 40 cents per pound of copper. Term contracts were much less volatile and averaged about 13 cents per pound during the fourth quarter.

Global consumption of refined copper rose by about 130,000 t to about 18.2 Mt but remained slightly below the level in 2007. Based on revised data, copper consumption in 2007 had risen by almost 1.2 Mt (7%). In 2009, for the third consecutive year, Asia, where apparent consumption rose by 18%, was the only major consuming region to experience demand growth. In China, where apparent consumption rose by a relatively modest 5% in 2008, apparent consumption rose by 38% to reach 7.18 Mt. China, which emerged as the leading world consumer in 2002 when it surpassed the United States, increasingly dominated global consumption with an almost 40% market share in 2009, up from only 11% in 1999. Note, however, that apparent consumption calculations for China do not include changes in unreported inventories that were thought to have been drawn down in 2008 and then built up in 2009. During 2009, China's growth in apparent refined copper consumption exceeded its growth in semimanufacture production. It was thought that significant growth in unreported inventories of refined copper and substitution of refined copper for scrap, contributed to the disparity. In India and the Republic of Korea, consumption rose by 7% and 16%, respectively, while in Japan and Taiwan, consumption declined by 26% and 15%, respectively. Consumption in North America, which accounted for 11% of global consumption in 2009, declined by 19% from that in 2008, and in Europe, which held a 21% market share, year-on-year consumption was down by 21% (International Copper Study Group, 2009, p. 25; 2010a, p. 19–20).

Owing to the global recession and overall lower commodity prices, relatively little global realignment of the copper industry took place during 2009. Corporación Nacional del Cobré de Chile (Codelco) regained its position as the leading global mine producer of copper, having narrowly relinquished that title in 2008 to FCX following FCX's acquisition of Phelps Dodge Corp. in 2007. Production by Codelco and FCX rose by

230,000 t and 100,000 t, respectively. BHP Billiton, Xstrata plc (Zug, Switzerland) (exclusive of Glencore's approximate 30% share), and Rio Tinto retained their positions as the third, fourth, and fifth leading producers, respectively. Combined, the top five producers accounted for 35% of global mine production. Codelco retained its position as the leading producer of refined copper and Norddeutsce Affinerie AG (Hamburg, Germany), renamed Arubis AG effective April 1, 2009, rose to second place following the acquisition of Cumerio SA (Olen, Belgium) in March 2008. FCX fell to the third ranked producer, Jiangxi Copper Corp. (Guixi City, Jiangxi Province, China) rose to fourth, and Xstrata fell to the fifth position. The top 5 producers accounted for 26% of global copper mine production, and the top 10 producers accounted for 46% (CRU International Ltd., 2010b, p. 266).

Mine Production.—In 2009, world mine production capacity continued its strong upward growth and, according to ICSG estimates, increased by about 750,000 t (4%). Significant capacity growth took place in Australia (105,000 t), China (40,000 t), Congo (Kinshasa) (150,000 t), and Zambia (225,000 t). The remaining growth was attributable to small (less than 40,000-t increases) in several other countries. In Chile and Peru, the two leading growth engines for copper mine capacity in the past decade, capacity was essentially unchanged in 2009 (International Copper Study Group, 2010b, p. 17; c, p. 17).

In Australia, OZ Minerals Ltd. (Melbourne, Australia) began production in February at its Prominent Hill Mine. At capacity, it was expected to produce 110,000 t/yr of copper in concentrate for at least 4 years. In Congo (Kinshasa), capacity continued to increase at several mines that began production in 2007, including 15,000 t/yr of additional concentrate production capacity at the Frontier Mine (First Quantum Minerals Ltd., Vancouver); 30,000 t/yr of additional electrowon capacity at the Kamoto Mine (Katanga Mining Ltd., Baar, Switzerland); 60,000 t/yr of additional electrowon capacity at the Luita Mine (Cental African Mining and Exploration Co., London); and 16,000 t/yr of additional electrowon capacity at the Ruashi II Mine (Metorex Ltd., Johannesburg, South Africa). The Tenke Fungarume Mine (57.75% owned by FCX), which along with Prominent Hill were the only significant greenfield startups in 2009, began production in March and was expected to reach full capacity of 115,000 t/yr in 2010. In Zambia, the Kansanshi Mine (First Quantum Minerals) increased concentrate and electrowon capacities by 15,000 t/yr and 30,000t/yr, respectively; the Lumwana Mine (Equinox Minerals Ltd., Perth, Australia, and Toronto) reached capacity of 170,000 t/yr following a delayed startup in 2008 owing to a fire (International Copper Study Group, 2010b, p. 34–73).

The global mine capacity utilization rate fell for the fourth consecutive year to about 81.5% in 2009 and was at its lowest level in more than 10 years. Production in 2009 continued to suffer from a number of technical and geopolitical problems that plagued production in the previous several years, but was more significantly affected by project delays and cutbacks inspired by the rapid decline in copper prices. According to CRU International Ltd., almost 700,000 t of mine cutbacks or closures had been announced by the end of the first quarter of 2009 (CRU International Ltd., 2009a, p. 6). Average production costs for most producers, which had risen sharply from 2006 to 2008, stabilized or declined during 2009, in part owing to these cutbacks, and in part owing to lower input costs. FCX reported that its North American net unit cash costs decreased to $1.11 per pound of copper from $1.33 per pound in 2008, despite lower molybdenum byproduct credits, owing to cost reductions and efficiency improvements, including lower operating rates, and to lower energy costs. FCX's South American production costs, inclusive of gold and molybdenum credits, decreased to $1.12 per pound of copper from $1.14 per pound in 2008 (Freeport-McMoRan Copper & Gold Inc., 2010a, p. 6–7). Grupo México reported that Southern Copper Corp. lowered its cash operating costs to $1.34 per pound of copper, exclusive of byproduct credits, from $1.63 per pound in 2008 (Grupo México, S.A.B. de C.V., 2010a, p. 8).

Smelter and Refinery Production.—According to the ICSG, world smelter production capacity rose by about 700,000 t/yr to 18.2 million metric tons per year (Mt/yr), mostly because of increases from operations being expanded during 2006 to 2009. China (410,000 t/yr), Chile, (85,000 t/yr), Poland (60,000 t/yr), Zambia (55,000 t/yr), and the Republic of Korea (40,000 t/yr) accounted for most of the increase in smelter capacity. In Chile, expansions of the Al Norte (Xstrata) and Codelco Norte smelters were completed; in China expansions of the Guixi (Jiangxi Copper Corp.), Jinchuan (Jinchuan Nonferrous Metals Group), and Tongling II (Tongling Nonferrous Metals Corp.) smelters were completed; and in Poland, the Glogow I (KGHM) blast furnace was replaced by a higher capacity flash smelter. In Zambia, the Chambishi [China Nonferrous Metal Mining (Group) Co., Ltd.] Isasmelt process smelter (150,000 t/yr), and the Nchanga (Konkola Copper Mines) Outokumpu flash smelter (250,000 t/yr at full capacity) were the only greenfield smelters to come onstream in 2009, though the latter was a replacement for the Nkana reverberatory smelter closed during 2009 (International Copper Study Group, 2010b, p. 71–80; 2010c, p. 58–81).

Global copper refinery capacity rose by 840,000 t/yr to 23.6 Mt/yr. About 300,000 t/yr of the refinery capacity increase came from electowinning associated with mine leach operations, mostly in Congo (Kinshasa) (150,000 t/yr), Chile (115,000 t/yr), and Zambia (50,000 t/yr), partially offset by declines in Australia and the United States. Electrolytic refinery capacity increases in China (340,000 t/yr) and Zambia (110,000 t/yr) were mostly related to smelter expansions. In China, the greenfield Baiyin electrolytic refinery (Baiyin Nonferrous Metals) was constructed to match existing smelter capacity of 100,000 t/yr. Its projected capacity of 300,000 t/yr was expected to exceed the proposed expansion of the Baiyan smelter to 200,000 t/yr (International Copper Study Group, 2010b, p. 71–83; 2010c, p. 81–109).

Outlook

Refined copper prices, which began 2010 above $3.00 per pound, fluctuated sharply through several cycles during the first 9 months of the year, the LME price ranging between $2.76 per pound (June 7) and $3.65 per pound (September 30), and averaging $3.25 during the period. Though fluctuating on a daily basis, copper prices maintained an upward trend during the fourth quarter of 2010 with the COMEX price averaging \$3.77 per pound of copper in October and \$3.84 per pound in November. In December, prices began a precipitous climb, the COMEX price surpassing the previous record-high price of \$4.08 (July 2, 2008) on December 8 and climbing to a new record-high of \$4.44 per pound at yearend. According to preliminary ICSG data, world apparent consumption of refined copper for 2010 totaled 19.4 Mt, an increase of 1.25 Mt (7%) from that in 2009, exceeding production of refined copper by about 300,000 t. While refined copper production rose by about 770,000 t in 2010 from that in 2009, world mine production rose by only about 160,000 t. Most of the discrepancy between mine and refinery production growth was attributed to increased production of secondary refined copper, which rose to 3.32 Mt from 2.79 Mt during the same comparative periods (International Copper Study Group, 2011).

In the United States, mine and refinery production continued to decline in 2010 owing to mine cutbacks instituted at yearend 2008 and lower ore grades. The White Pine electrolytic refinery in Michigan that treated imported anode closed in August. U.S. copper mine production was expected to rise by more than 100,000 t in 2011 owing to expansions and restoration of cutbacks. Domestic consumption of refined copper rose by about 5% in 2010 but remained below the 2008 level.

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TABLE 1
SALIENT COPPER STATISTICS[1]

(Metric tons, unless otherwise specified)

		2005	2006	2007	2008	2009
United States:						
Mine production:						
Ore concentrated	thousand metric tons	154,000	163,000	138,000	156,000	149,000
Average yield of concentrated ore	percent	0.37	0.40	0.46 [r]	0.50	0.46
Recoverable copper:						
Arizona		690,000	712,000	731,000	836,000	711,000
New Mexico		131,000	113,000	108,000	104,000	56,500
Other States		319,000	372,000	329,000	368,000	414,000
Total		1,140,000	1,200,000	1,170,000	1,310,000	1,180,000
Total value	millions	$4,360	$8,310	$8,450	$9,200	$6,290
Smelter production:						
Primary and secondary		523,000	501,000	617,000	574,000	597,000
Byproduct sulfuric acid, sulfur content	thousand metric tons	575	576	720	655	682 [e]
Refinery production:						
Primary materials:						
Electrolytic from domestic ores		524,000	531,000	702,000	603,000	588,000
Electrolytic from foreign materials		130,000	144,000	62,100	109,000	48,300
Electrowon		554,000	530,000	504,000	507,000	476,000
Total		1,210,000	1,210,000	1,270,000	1,220,000	1,110,000
Secondary materials (scrap), electrolytic and fire refined		47,200	44,800	46,000	53,800	46,400
Grand total		1,260,000	1,250,000	1,310,000	1,270,000	1,160,000
Secondary copper produced:						
Recovered from new scrap		769,000	819,000	767,000	697,000	638,000
Recovered from old scrap		183,000	151,000	158,000	156,000 [r]	137,000
Total		953,000	969,000	925,000	852,000 [r]	774,000
Copper sulfate production		25,600	19,500	22,600	22,000	22,400
Exports, refined		39,500	106,000	51,100	36,500	80,800
Imports, refined		1,000,000	1,070,000	829,000	724,000	664,000
Stocks, December 31:						
Blister and in-process material		44,300	18,800	26,300	24,100 [r]	15,500
Refined copper:						
Refineries		8,190	28,100	21,800	18,300 [r]	23,700
Wire-rod mills		20,400	21,500	20,600	31,700 [r]	25,300
Brass mills		24,500	34,500	10,400	8,340	7,610
Other industry		3,350	3,280	3,220	3,230	4,290
COMEX		6,180	30,900	13,500	31,300	90,000
London Metal Exchange (LME), U.S. warehouses		800	75,600	60,600	106,000	283,000
Total		63,500	194,000	130,000	199,000 [r]	434,000
Consumption:						
Refined copper, reported		2,270,000	2,110,000	2,140,000	2,020,000	1,650,000
Apparent consumption, primary refined and old scrap[2]		2,420,000	2,200,000	2,270,000	1,990,000 [r]	1,580,000
Price:						
Producer, weighted average	cents per pound	173.49	314.75	328.00	319.16	241.24
COMEX, first position	do.	168.23	308.94	322.17	313.35	235.42
LME, Grade A cash	do.	166.84	304.85	322.83	315.47	233.56
World, production:						
Mine	thousand metric tons	15,000	15,100 [r]	15,500	15,400	15,900 [e]
Smelter	do.	13,500 [r]	14,100 [r]	14,300	14,700	14,500 [e]
Refinery	do.	16,600 [r]	17,300	17,900 [r]	18,300 [r]	18,400 [e]

[e]Estimated. [r]Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits, except prices; may not add to totals shown.

[2] In 2005, 2006, 2007, 2008, and 2009, apparent consumption is calculated using general imports of 977,000 metric tons (t), 1,080,000 t, 832,000 t, 721,000 t, and 645,000 t, respectively.

TABLE 2
LEADING COPPER-PRODUCING MINES IN THE UNITED STATES IN 2009, IN ORDER OF OUTPUT[1]

Rank	Mine	County and State	Operator	Source of copper	Capacity (thousand metric tons)
1	Bingham Canyon	Salt Lake, UT	Kennecott Utah Copper Corp.[2]	Copper-molybdenum ore, concentrated and leached	300
2	Morenci	Greenlee, AZ	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum ore, concentrated and leached	400
3	Bagdad	Yavapai, AZ	do.	do.	110
4	Ray	Pinal, AZ	ASARCO LLC	Copper ore, concentrated and leached	140
5	Sierrita	Pima, AZ	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum ore, concentrated and leached	90
6	Safford	Graham, AZ	do.	Copper ore, leached	110
7	Mission Complex	Pima, AZ	ASARCO LLC	Copper-molybdenum ore, concentrated	70
8	Robinson	White Pine, NV	Quadra Mining Ltd.	do.	70
9	Tyrone	Grant, NM	Freeport-McMoRan Copper & Gold Inc.	Copper ore, leached	50
10	Continental Pit	Silver Bow, MT	Montana Resources	Copper-molybdenum ore, concentrated	40
11	Silver Bell	Pima, AZ	ASARCO LLC	Copper ore, leached	22
12	Chino	Grant, NM	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum ore, leached	135
13	Phoenix	Lander, NV	Newmont Mining Corp.	Gold-copper ore, concentrated	15
14	Mineral Park	Mohave, AZ	Mercator Minerals Ltd.	Copper-molybdenum ore, concentrated and leached	17
15	Carlota	Gila, AZ	Quadra Mining Ltd.	Copper ore, leached	25
16	Miami	do.	Freeport-McMoRan Copper & Gold Inc.	do.	50
17	Pinto Valley	do.	BHP Billiton	do.	75
18	Lisbon Valley	San Juan, UT	Constellation Copper Corp.	do.	5

do. Ditto.

[1] The mines on this list accounted for more than 99% of U.S. mine production in 2009.

[2] Wholly owned subsidiary of Rio Tinto plc.

TABLE 3
MINE PRODUCTION OF COPPER-BEARING ORES AND RECOVERABLE COPPER CONTENT OF ORES PRODUCED IN THE UNITED STATES, BY SOURCE AND TREATMENT PROCESS[1]

(Metric tons)

	2008		2009	
Source and treatment process	Gross weight[2]	Recoverable copper	Gross weight[2]	Recoverable copper
Mined copper ore:				
Concentrated	156,000,000	773,000 r	149,000,000	683,000
Leached	NA	507,000	NA	476,000
Total	NA	1,280,000 r	NA	1,160,000
Copper precipitates shipped, leached from tailings, dumps, and in-place material	NA	3,490	NA	W
Other copper-bearing ores[3]	5,300,000	23,600 r	4,480,000	21,900
Grand total	XX	1,310,000	XX	1,180,000

r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; included with "Other copper-bearing ores." XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] In 2009, 23,300 kilograms of gold and 274 metric tons of silver were recovered from concentrated ore. The average value of gold and silver per metric ton of ore concentrated was $3.07.

[3] Includes gold ore, lead ore, silver ore, and zinc ore.

TABLE 4

CONSUMPTION OF COPPER AND BRASS MATERIALS IN THE UNITED STATES, BY ITEM[1]

(Metric tons)

Item	Brass mills	Wire-rod mills	Foundries, chemical plants, miscellaneous users	Smelters, refiners, ingot makers	Total
2008:					
Copper scrap	739,000 [r, 2]	W	64,700 [r]	193,000 [r]	997,000 [r]
Refined copper[3]	479,000	1,490,000	45,500	4,520 [r]	2,020,000
Hardeners and master alloys	10,000	--	2,930	--	13,000
Brass ingots	--	--	77,700 [r]	--	77,700 [r]
Slab zinc	44,300	--	(4)	(4)	107,000
2009:					
Copper scrap	688,000 [2]	W	66,500	159,000	914,000
Refined copper[3]	454,000	1,140,000	49,500	4,510	1,650,000
Hardeners and master alloys	9,990	--	3,090	--	13,100
Brass ingots	--	--	55,500	--	55,500
Slab zinc	44,800	--	(4)	(4)	107,000

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Brass mills." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes item indicated by symbol W.

[3] Detailed information on consumption of refined copper can be found in table 5.

[4] Withheld to avoid disclosing company proprietary data; included in "Total."

TABLE 5

CONSUMPTION OF REFINED COPPER SHAPES IN THE UNITED STATES, BY CLASS OF CONSUMER[1]

(Metric tons)

Class of consumer	Cathodes	Ingots and ingot bars	Cakes and slabs	Wirebar, billets, other	Total
2008:					
Wire-rod mills	1,490,000	--	W	2,890	1,490,000
Brass mills	323,000	24,200	45,000	86,300	479,000
Chemical plants	--	--	--	344	344
Ingot makers	W	W	W	4,520 [2]	4,520
Foundries	4,670	4,440	--	11,300	20,400
Miscellaneous[3]	W	W	W	24,700 [2]	24,700
Total	1,820,000	28,600	45,000	130,000	2,020,000
2009:					
Wire-rod mills	1,140,000	--	--	4,620	1,140,000
Brass mills	313,000	24,200	43,600	72,800	454,000
Chemical plants	--	--	--	367	367
Ingot makers	W	W	W	4,510 [2]	4,510
Foundries	3,450	3,240	--	12,400	19,100
Miscellaneous[3]	W	W	W	30,100 [2]	30,100
Total	1,450,000	27,400	43,600	125,000	1,650,000

W Withheld to avoid disclosing company proprietary data; included with "Wirebar, billets, other." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes items indicated by symbol W.

[3] Includes consumers of copper powder and copper shot, iron and steel plants, and other manufacturers.

TABLE 6
COPPER RECOVERED FROM SCRAP PROCESSED IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY[1]

(Metric tons)

	2008	2009
Kind of scrap:		
New scrap:		
Copper-base	659,000	608,000
Aluminum-base	37,700 [r]	29,400
Nickel-base	18	18
Total	697,000	638,000
Old scrap:		
Copper-base	133,000 [r]	120,000
Aluminum-base	22,900 [r]	16,700
Nickel-base	275	267
Zinc-base	9	9
Total	156,000 [r]	137,000
Grand total	852,000 [r]	774,000
Form of recovery:		
As unalloyed copper	55,000	47,100
In brass and bronze	731,000 [r]	675,000
In alloy iron and steel	677	673
In aluminum alloys	60,700 [r]	46,100
In other alloys	8	8
In chemical compounds	5,040	5,030
Total	852,000 [r]	774,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 7
COPPER RECOVERED AS REFINED COPPER AND IN ALLOYS AND OTHER FORMS FROM COPPER-BASE SCRAP PROCESSED IN THE UNITED STATES, BY TYPE OF OPERATION[1]

(Metric tons)

Type of operation	From new scrap		From old scrap		Total	
	2008	2009	2008	2009	2008	2009
Ingot makers	15,400 [r]	11,500	76,500 [r]	62,400	91,900 [r]	73,900
Refineries[2]	26,900	20,800	26,900	25,600	53,800	46,400
Brass and wire-rod mills	584,000	545,000	17,000	16,500	601,000	561,000
Foundries and manufacturers	27,200	25,900	12,300	15,200	39,500	41,000
Chemical plants	5,030	5,030	6	--	5,040	5,030
Total	659,000	608,000	133,000 [r]	120,000	792,000 [r]	728,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes electrolytically refined based on source of material at smelter level.

TABLE 8

PRODUCTION OF SECONDARY COPPER AND COPPER-ALLOY PRODUCTS IN THE UNITED STATES, BY ITEM PRODUCED FROM SCRAP[1]

(Metric tons)

Item produced from scrap	2008	2009
Unalloyed copper products:		
Refined copper	53,800	46,400
Copper powder	1,070	587
Copper castings	136	82
Total	55,000	47,100
Alloyed copper products:		
Brass and bronze ingots:		
Tin bronzes	9,050	6,890
Leaded red brass and semired brass	65,300	52,400
High leaded tin bronze	10,400	7,330
Yellow brass	5,570	4,870
Manganese bronze	7,660	7,260
Aluminum bronze	6,600	5,860
Nickel silver	1,570	1,060
Silicon bronze and brass	5,750	4,710
Copper-base hardeners and master alloys	7,660	7,670
Miscellaneous	6,270	6,090
Total	126,000	104,000
Brass mill and wire-rod mill products	725,000	678,000
Brass and bronze castings	38,600	38,300
Copper in chemical products	5,040	5,030
Grand total	949,000	873,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 9

COMPOSITION OF SECONDARY COPPER-ALLOY PRODUCTION IN THE UNITED STATES[1]

(Metric tons)

	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze ingot production:[2]							
2008	106,000 [r]	3,810 [r]	5,830 [r]	10,500	160	12	126,000
2009	85,900	3,610	5,320	9,220	116	11	104,000
Secondary metal content of brass mill products:							
2008	601,000	1,400	2,580	118,000	1,390	18	725,000
2009	565,000	1,180	2,270	109,000	860	16	678,000
Secondary metal content of brass and bronze castings:							
2008	35,200	1,170 [r]	604	1,450	81	74	38,600
2009	34,800	1,170	572	1,500	134	97	38,300

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes approximately 96% from scrap and 4% from other than scrap in 2008 and 2009.

TABLE 10

CONSUMPTION AND YEAREND STOCKS OF COPPER-BASE SCRAP[1]

(Metric tons, gross weight)

Scrap type and processor	2008		2009	
	Consumption	Stocks	Consumption	Stocks
Unalloyed scrap:				
No. 1 wire and heavy:				
Smelters, refiners, and ingot makers	61,800	1,240 r	45,000	968
Brass and wire-rod mills	353,000	(2)	332,000	(2)
Foundries and miscellaneous manufacturers	19,000	(2)	16,800	(2)
No. 2 mixed heavy and light:				
Smelters, refiners, and ingot makers	42,300 r	2,650 r	40,600	2,240
Brass and wire-rod mills	12,600	(2)	8,590	(2)
Foundries and miscellaneous manufacturers	3,130	(2)	6,450	(2)
Total unalloyed scrap:				
Smelters, refiners, and ingot makers	104,000	3,890 r	85,600	3,210
Brass and wire-rod mills	366,000	13,500	341,000	14,100
Foundries and miscellaneous manufacturers	22,200	1,490	23,300	1,670
Alloyed scrap:				
Red brass:[3]				
Smelters, refiners, and ingot makers	26,900 r	1,400 r	20,600	1,550
Brass mills	11,700	(2)	9,230	(2)
Foundries and miscellaneous manufacturers	5,480	(2)	5,950	(2)
Leaded yellow brass:				
Smelters, refiners, and ingot makers	11,500 r	735 r	9,970	640
Brass mills	132,000	(2)	116,000	(2)
Foundries and miscellaneous manufacturers	1,230	(2)	1,000	(2)
Yellow and low brass, all plants	143,000	509 r	127,000	525
Cartridge cases and brass, all plants	74,100	(2)	87,800	(2)
Auto radiators:				
Smelters, refiners, and ingot makers	26,000 r	666 r	20,200	774
Foundries and miscellaneous manufacturers	1,950	(2)	1,900	(2)
Bronzes:				
Smelters, refiners, and ingot makers	12,800 r	806 r	10,800	612
Brass mills and miscellaneous manufacturers	16,100	(2)	15,800	(2)
Nickel-copper alloys, all plants	13,100	148 r	8,460	117
Low grade and residues; smelters, refiners, miscellaneous manufacturers	23,300	588 r	23,300	598
Other alloy scrap:[4]				
Smelters, refiners, and ingot makers	1,140 r	230 r	1,110	191
Brass mills and miscellaneous manufacturers	4,990	(2)	5,270	(2)
Total alloyed scrap:				
Smelters, refiners, and ingot makers	89,200 r	5,080 r	73,700	5,010
Brass mills	373,000	22,200	347,000	18,300
Foundries and miscellaneous manufacturers	42,600	2,180 r	43,200	2,940
Total scrap:				
Smelters, refiners, and ingot makers	193,000 r	8,970 r	159,000	8,220
Brass and wire-rod mills	739,000	35,800	688,000	32,500
Foundries and miscellaneous manufacturers	64,700 r	3,670 r	66,500	4,610

r Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Individual breakdown is not available; included in "Total unalloyed scrap," "Total alloyed scrap," and "Total scrap."

[3] Includes cocks and faucets, commercial bronze, composition turnings, gilding metal, railroad car boxes, and silicon bronze.

[4] Includes aluminum bronze, beryllium copper, and refinery brass.

TABLE 11
CONSUMPTION OF PURCHASED COPPER-BASE SCRAP[1, 2]

(Metric tons, gross weight)

Type of operation	From new scrap 2008	From new scrap 2009	From old scrap 2008	From old scrap 2009	Total 2008	Total 2009
Ingot makers	34,600 [r]	34,500	105,000	77,600	140,000	112,000
Smelters and refineries	28,700	24,300	25,100	22,900	53,800	47,200
Brass and wire-rod mills	721,000	671,000	17,200	16,900	739,000	688,000
Foundries and miscellaneous manufacturers	50,700	48,200	14,000	18,300	64,800	66,500
Total	836,000 [r]	778,000	161,000	136,000	997,000 [r]	914,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Consumption at brass and wire-rod mills assumed equal to receipts.

TABLE 12
FOUNDRIES AND MISCELLANEOUS MANUFACTURERS CONSUMPTION OF BRASS INGOT, REFINED COPPER, AND COPPER SCRAP IN THE UNITED STATES[1]

(Metric tons)

Ingot type or material consumed	2008	2009
Tin bronzes	13,800	8,340
Leaded red brass and semired brass	47,600 [r]	33,700
Yellow, leaded, low brass[2]	7,020 [r]	6,080
Manganese bronze	3,460	2,240
Nickel silver[3]	498	620
Aluminum bronze	3,580	3,020
Hardeners and master alloys[4]	2,930	3,090
Lead free alloys[5]	1,650	1,420
Total brass ingot	80,600 [r]	58,500
Refined copper	45,500	49,500
Copper scrap	64,800	66,500

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes brass and silicon bronze.

[3] Includes brass, copper nickel, and nickel bronze.

[4] Includes special alloys.

[5] Includes copper-bismuth and copper-bismuth-selenium alloys.

TABLE 13
AVERAGE PRICES FOR COPPER SCRAP, BY TYPE

(Cents per pound)

			Dealers' buying (New York)	
Year	Brass mills No. 1 scrap	Refiners No. 2 scrap	No. 2 scrap	Red brass turnings and borings
2008	300.55	279.08	217.11	143.85
2009	226.83	205.85	159.16	112.93

Source: American Metal Market.

TABLE 14

U.S. EXPORTS OF UNMANUFACTURED COPPER (COPPER CONTENT), BY COUNTRY[1]

Country	Ore and concentrate[2] Quantity (metric tons)	Ore and concentrate[2] Value (thousands)	Matte, ash, and precipitates Quantity (metric tons)	Matte, ash, and precipitates Value (thousands)	Refined Quantity (metric tons)	Refined Value (thousands)	Unalloyed copper scrap Quantity (metric tons)	Unalloyed copper scrap Value (thousands)	Blister and anodes Quantity (metric tons)	Blister and anodes Value (thousands)	Total Quantity (metric tons)	Total Value (thousands)
2008	301,000	$1,530,000	46,200	$99,200	36,500	$182,000	278,000	$1,320,000	23,500	$112,000	686,000[r]	$3,240,000[r]
2009:												
Belgium	1	7	609	1,080	16	27	2,160	7,750	118	384	2,900	9,250
Canada	22,400	96,900	35,700	52,100	11,200	51,300	6,320	34,800	14,100	35,800	89,800	271,000
China	57,500	284,000	1,260	6,230	41,400	190,000	190,000	617,000	573	3,350	291,000	1,100,000
Germany	--	--	1,690	2,270	99	564	1,510	6,510	3,300	15,000	6,600	24,300
Hong Kong	(3)	3	--	--	3,570	21,100	15,600	63,100	1,740	10,100	20,900	94,300
India	--	--	--	--	59	154	356	1,480	148	844	563	2,470
Japan	21,400	124,000	176	997	81	463	3,220	15,900	478	2,860	25,400	144,000
Korea, Republic of	9,030	50,500	--	--	23	88	8,400	36,500	2,920	18,900	20,400	106,000
Mexico	36,700	166,000	--	--	7,950	36,200	1,580	8,770	44	257	46,200	211,000
Taiwan	--	--	75	347	534	2,240	6,980	23,300	441	2,020	8,030	27,900
Other	3,770	22,100	1,420	813	15,900	72,700	8,420	40,900	2,070	9,210	31,600	146,000
Total	151,000	743,000	40,900	63,800	80,800	375,000	245,000	856,000	26,000	98,600	543,000	2,140,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Data for 2009 adjusted by the U.S. Geological Survey to reflect estimated copper content.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 15
U.S. EXPORTS OF COPPER SEMIMANUFACTURES, BY COUNTRY[1]

Country	Pipes and tubing		Plates, sheets, foil, bars		Bare wire, including wire rod[2]		Wire and cable, stranded		Copper sulfate	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2008	24,900	$226,000	31,900	$283,000	139,000	$1,160,000	20,700	$196,000	5,430	$9,700
2009:										
Australia	26	219	25	199	8	104	55	626	--	--
Brazil	20	203	32	401	3	96	17	310	1	4
Canada	4,640	39,300	9,160	54,600	34,600	185,000	5,910	36,400	2,420	4,810
China	121	1,180	2,100	9,020	1,780	7,300	578	9,960	399	744
Denmark	(3)	5	9	368	1	5	5	185	--	--
France	1	44	28	394	8	144	37	1,220	1	4
Germany	3	63	99	2,170	382	9,310	47	2,630	36	61
Hong Kong	15	86	100	1,190	172	773	82	1,960	--	--
Italy	18	320	27	219	15	289	8	190	79	63
Japan	3	36	127	2,410	13	227	236	2,230	6	5
Korea, Republic of	71	806	490	3,410	22	305	165	3,160	11	37
Malaysia	19	147	107	1,210	75	2,900	14	470	23	30
Mexico	13,500	99,600	6,420	48,700	86,900	446,000	8,890	54,400	141	231
Netherlands	38	345	50	1,070	15	263	28	1,300	72	73
Saudi Arabia	1,080	7,620	64	422	--	--	149	1,680	56	45
Singapore	17	143	74	523	19	131	144	2,060	5	6
Sweden	--	--	6	20	39	346	3	69	1	5
Taiwan	--	--	1,120	5,020	8	192	34	826	754	1,040
Thailand	19	246	39	540	26	264	15	287	--	--
United Kingdom	410	2,330	23	373	78	665	238	2,430	--	--
Other	1,250	11,300	588	5,450	1,430	13,600	3,760	40,300	1,880	2,550
Total	21,200	164,000	20,700	138,000	126,000	668,000	20,400	163,000	5,880	9,700

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Total exports of wire rod in 2008 were 126,000 metric tons (t) valued at $1,010 million, and in 2009, wire rod exports were 112,000 t valued at $594 million.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 16

U.S. IMPORTS FOR CONSUMPTION OF UNMANUFACTURED COPPER (COPPER CONTENT), BY COUNTRY[1]

Country	Ore and concentrate		Matte, ash, and precipitates		Blister and anode		Refined		Unalloyed scrap		Total	
	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
2008	640	$1,030	1,170	$5,140	122,000	$912,000	724,000	$5,290,000	32,800	$172,000	881,000	$6,380,000
2009:												
Belgium	--	--	7	33	--	--	5	32	--	--	12	65
Brazil	--	--	--	--	--	--	10,800	49,300	--	--	10,800	49,300
Canada	137	271	420	1,260	61,800	303,000	189,000	919,000	7,340	32,500	259,000	1,260,000
Chile	--	--	--	--	--	--	312,000	1,460,000	25	151	312,000	1,460,000
Costa Rica	--	--	--	--	--	--	--	--	275	436	275	436
Dominican Republic	--	--	--	--	--	--	--	--	753	1,100	753	1,100
Finland	--	--	--	--	266	1,210	(3)	5	--	--	266	1,210
Germany	--	--	22	139	(3)	11	2,510	13,300	88	54	2,620	13,500
Honduras	--	--	--	--	--	--	--	--	474	933	474	933
Japan	--	--	66	38	6	569	3,600	22,600	16	35	3,690	23,200
Mexico	--	--	--	--	6,270	82,800	19,600	96,900	4,840	11,500	30,700	191,000
Peru	--	--	--	--	--	--	124,000	552,000	--	--	124,000	552,000
Taiwan	--	--	15	56	--	--	--	--	--	--	15	56
United Kingdom	--	--	--	--	6	269	(3)	27	--	--	7	297
Other	--	--	229	741	137	979	1,510	9,330	2,480	5,300	4,360	16,400
Total	137	271	759	2,260	68,400	389,000	664,000	3,120,000	16,300	52,000	749,000	3,570,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, freight value at U.S. port.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 17

U.S. IMPORTS FOR CONSUMPTION OF COPPER SEMIMANUFACTURES, BY COUNTRY[1]

Country	Pipes and tubing		Plates, sheets, foil, bars		Bare wire, including wire rod[2]		Wire and cable, stranded		Copper sulfate	
	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)
2008	970	$11,100	61,700 r	$560,000 r	163,000	$1,220,000	18,600	$172,000	56,800	$125,000
2009:										
Australia	--	--	--	--	20	134	(4)	11	--	--
Belgium	--	--	155	2,000	(4)	3	--	--	1	5
Brazil	--	--	849	4,690	2	15	1	11	--	--
Canada	7	90	442	3,140	89,500	458,000	302	2,740	4,350	6,540
Chile	8	64	3,390	18,300	--	--	--	--	4,140	7,120
China	219	681	1,800	10,900	63	1,070	60	444	5,320	13,400
Finland	94	1,300	1,740	14,400	300	1,880	49	238	1	5
France	1	157	1,630	9,480	22	839	25	531	--	--
Germany	319	3,450	16,300	117,000	692	5,260	450	3,560	342	376
Israel	--	--	16	99	144	1,050	--	--	--	--
Italy	(4)	15	24	223	4	137	10	138	(4)	3
Japan	(4)	9	1,510	14,800	262	5,350	(4)	39	32	581
Korea, Republic of	(4)	20	749	3,910	7	101	1,080	6,120	--	--
Luxembourg	--	--	1,170	12,600	--	--	--	--	--	--
Mexico	982	6,630	4,170	23,700	9,020	42,800	465	2,490	31,300	54,000
Peru	--	--	3,950	22,200	325	1,590	8	37	266	417
Russia	--	--	--	--	18,300	61,300	--	--	1,020	1,890
Sweden	--	--	3,240	22,000	110	1,360	--	--	--	--
Taiwan	1	12	144	1,840	126	700	15	322	2,320	3,540
Turkey	--	--	1	7	22	113	7,470	44,800	--	--
United Kingdom	(4)	26	455	3,460	82	198	1	58	--	--
Other	43	216	782	5,460	1,300	11,400	950	8,010	269	433
Total	1,670	12,700	42,500	290,000	120,000	594,000	10,900	69,600	49,300	88,200

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Total imports of wire rod in 2008 were 156,000 metric tons (t) valued at $1.15 billion, and in 2009, wire rod imports were 113,000 t valued at $542 million.

[3] Cost, insurance, freight value at U.S. port.

[4] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 18
U.S. EXPORTS OF COPPER SCRAP, BY COUNTRY[1]

	Unalloyed copper scrap				Copper-alloy scrap			
	2008		2009		2008		2009	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Belgium	2,570	$7,370	2,160	$7,750	17,900	$41,700	14,900	$31,800
Canada	9,830	65,900	6,320	34,800	39,000	156,000	32,300	91,500
China	186,000	787,000	190,000	617,000	421,000	977,000	416,000	693,000
Germany	4,280	14,200	1,510	6,510	10,300	48,500	6,600	31,900
Hong Kong	21,200	124,000	15,600	63,100	50,800	100,000	37,400	85,600
India	1,970	3,570	356	1,480	9,340	26,900	11,100	23,200
Japan	8,720	59,400	3,220	15,900	13,100	65,500	10,200	46,200
Korea, Republic of	19,800	123,000	8,400	36,500	21,900	86,500	21,500	48,800
Mexico	1,960	12,800	1,580	8,770	5,970	37,200	9,990	41,300
Taiwan	4,900	26,400	6,980	23,300	9,920	16,800	6,510	5,680
Other	17,800	95,300	8,420	40,900	30,600	86,700	31,200	52,300
Total	278,000	1,320,000	245,000	856,000	630,000	1,640,000	598,000	1,150,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 19
U.S. IMPORTS FOR CONSUMPTION OF COPPER SCRAP, BY COUNTRY[1]

	Unalloyed copper scrap		Copper-alloy scrap		
Country or territory	Quantity (metric tons)	Value[2] (thousands)	Gross weight (metric tons)	Copper content[3] (metric tons)	Value[2] (thousands)
2008	32,800	$172,000	73,500	53,000	$313,000
2009:					
Canada	7,340	32,500	24,900	17,900	97,300
Chile	25	151	230	166	1,060
Costa Rica	275	436	1,290	929	4,760
Dominican Republic	753	1,100	907	653	1,020
Guatemala	272	490	433	312	1,300
Honduras	474	933	355	256	1,320
Jamaica	198	303	334	241	402
Mexico	4,840	11,500	22,900	16,500	64,400
Nicaragua	666	1,180	441	317	517
Peru	--	--	650	468	3,700
Other	1,450	3,420	3,100	2,230	9,620
Total	16,300	52,000	55,500	40,000	185,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.
[2] Cost, insurance, freight value at U.S. port.
[3] Content is estimated by the U.S. Geological Survey to be 72% of gross weight.

Source: U.S. Census Bureau.

TABLE 20

COPPER: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2005	2006	2007	2008	2009
Argentina	187,317	180,144	180,200	156,893 [r]	143,084
Armenia	16,400	18,000 [e]	17,600 [e]	18,800	22,600
Australia:					
Concentrates	865,300	806,400	828,000 [e]	833,000 [e]	831,000
Leaching, electrowon	51,000	52,400	42,000 [e]	53,000 [e]	23,000
Total	916,300	858,800	870,000 [e]	886,000 [e]	854,000
Bolivia	32 [r]	218	606	731	734
Botswana[e]	26,100	24,000	24,000	29,000	30,000
Brazil	133,325	147,836	205,728	219,676 [r]	213,100
Bulgaria	95,000	110,000	116,157 [r]	107,195 [r]	110,652
Burma, leaching, electrowon	34,478	19,500	15,100	6,900 [r]	5,000 [e]
Canada:					
Concentrates	595,383	603,295	594,749 [r]	605,399 [r]	489,800
Leaching, electrowon	--	--	1,500	1,600	800
Total	595,383	603,295	596,249	606,999	490,600
Chile:[3]					
Concentrates	3,735,900	3,669,000	3,724,900	3,356,600	3,276,900
Leaching, electrowon	1,584,600	1,691,800	1,832,100	1,971,000 [r]	2,112,700
Total	5,320,500	5,360,800	5,557,000	5,327,600 [r]	5,389,600
China:[e]					
Concentrates	762,000	873,000	928,000	940,000	970,000
Leaching, electrowon	15,000	16,000	18,000	20,000	25,000
Total	777,000	889,000	946,000	960,000	995,000
Colombia	2,189 [r]	725 [r]	1,050 [r]	1,310 [r]	1,420 [e]
Congo (Kinshasa):[4]					
Concentrates[e]	48,000 [r]	89,000 [r]	107,000 [r]	182,000 [r]	150,000 [e]
Leaching, electrowon	49,538	53,285	41,361 [r]	60,902 [r]	151,000 [e]
Total	97,538 [r]	142,285 [r]	148,361 [r]	242,902 [r]	301,000 [e]
Cyprus, leaching, electrowon	--	--	300 [e]	300 [e]	300 [e]
Dominican Republic	--	--	--	2,600	11,500
Finland	15,093 [r]	13,316 [r]	13,646 [r]	13,440 [r]	14,198
Georgia[e]	10,000	9,000	11,000	11,000	11,000
India	26,900	27,400	33,900	30,600 [r]	31,000
Indonesia[4]	1,064,200	818,000	796,900	632,600	996,000
Iran:[e]					
Concentrates	150,000	208,000	241,000	241,000	255,000
Leaching, electrowon	10,000	9,000	8,000	8,000	7,000
Total	160,000	217,000	249,000	249,000	262,000
Kazakhstan[e]	422,000	457,000	405,000	420,000	390,000
Korea, North[e]	12,000	12,000	12,000	12,000	12,000
Korea, Republic of	4,000	3,000	6,000	4,000	14,000
Laos:					
Concentrates	--	--	--	24,929	54,019
Leaching, electrowon	30,480	60,803	62,541 [r]	64,075	67,561
Total	30,480	60,803	62,541 [r]	89,004	121,580
Macedonia	--	33,591	33,467	38,337	35,430
Mauritania	--	5,031	31,956	33,073	35,000

See footnotes at end of table.

TABLE 20—Continued
COPPER: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2005	2006	2007	2008	2009
Mexico:					
Concentrates	336,376	241,536	230,500	172,093	170,597
Leaching, electrowon	92,675	86,000	107,000	74,500	57,151
Total	429,051	327,536	337,500	246,593	227,748
Mongolia	126,547	129,693	130,160	126,800 r	129,800
Morocco	3,800	4,600	5,572	5,600	5,500
Namibia	10,900	6,262	6,580 r	7,471 r	--
Pakistan	17,700	19,100	18,800	18,700	18,500
Papua New Guinea	192,978	194,355	169,184	159,650	166,700
Peru:					
Concentrates	844,369	874,601	1,018,156	1,107,789	1,106,025
Leaching, electrowon	165,530	173,871	172,118	160,078	168,700
Total	1,009,899	1,048,472	1,190,274	1,267,867	1,274,725
Philippines	16,323	17,161	22,862	21,235	49,060
Poland	512,000	497,000	452,000	429,000	444,000
Portugal	89,541	78,660 r	90,247 r	89,070 r	86,900
Romania[5]	15,000	12,132	2,213	2,732 r	585
Russia[e]	700,000	725,000	740,000	750,000	725,000 e
Saudi Arabia	668	730	750 e	1,465 r	2,000
Serbia	12,900 [6]	12,000	16,500	18,800 e	19,000 e
South Africa	88,600	89,500	97,000	97,185 r	92,852
Spain:					
Concentrates	4,892 r	6,616 r	6,281 r	7,071 r	15,400
Leaching, electrowon	--	--	--	--	5,600
Total	4,892	6,616	6,281	7,071	21,000
Sweden	97,800	86,746	62,905	57,400 e	56,000
Tanzania, in concentrates and bullion	3,661 r	3,284 r	3,275 r	2,700 e	5,800 e
Turkey[e, 5]	54,000	46,000	81,000	83,000	70,000
United States:[4]					
Concentrates	586,000	667,000	665,000	801,000	705,000
Leaching, electrowon	554,000	530,000	504,000	507,000	476,000
Total	1,140,000	1,200,000	1,170,000	1,310,000	1,180,000
Uzbekistan[e]	110,000	100,000	95,000	95,000	95,000
Zambia:[e]					
Concentrates	330,000	350,000 [7]	341,000 [7]	383,000	547,000
Leaching, electrowon	102,000 [7]	124,000	168,000	163,000	150,000
Total	432,000	474,000	509,000	546,000	697,000
Zimbabwe, concentrates[e]	2,570 [7]	2,581 [7]	3,000	2,000	3,000
Grand total	15,000,000 r	15,100,000 r	15,500,000	15,400,000	15,900,000
Of which:					
Concentrates	12,300,000 r	12,300,000	12,600,000	12,400,000	12,600,000
Leaching, electrowon	2,690,000 r	2,820,000 r	2,970,000 r	3,090,000 r	3,250,000

[e] Estimated. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table represent copper content by analysis of concentrates produced (includes cement copper, if applicable), except where otherwise noted. Table includes data available through July 28, 2010.

[3] Reported by Comision Chilena del Cobre. Includes recoverable copper content of nonduplicative mine and metal products produced from domestic ores and concentrates and leach production for electrowinning.

[4] Recoverable content.

[5] Excludes copper content of pyrite.

[6] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[7] Reported figure.

TABLE 21

COPPER: WORLD SMELTER PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country	2005	2006	2007	2008	2009
Armenia, primary	9,881	8,791	6,954	6,480 [r]	6,858
Australia, primary	410,000	377,000	399,000	449,000	422,000
Austria, secondary	52,700 [r]	65,900 [r]	80,200 [r]	94,200 [r]	90,800 [p]
Belgium, secondary	99,200	114,600	115,000 [e]	124,500	114,400
Botswana, primary[3]	26,704	24,255	19,996	23,146	24,382
Brazil:					
Primary	159,043 [r]	179,700 [r]	178,367 [r]	181,000 [r, e]	176,000 [e]
Secondary[e]	40,000	40,000	40,000	39,000	31,000
Total	199,043	219,700	218,367	220,000	207,000
Bulgaria:					
Primary	225,000	217,000	217,600	257,100	256,200
Secondary[e]	15,000	24,000	11,500	21,200	20,000
Total	240,000	241,000	229,100	278,300	276,200
Canada:					
Primary	441,325	484,675	470,713	443,798	316,510
Secondary	30,525	35,826	46,101	41,777	29,733
Total	471,850	520,501	516,814	485,575	346,243
Chile, primary	1,558,100	1,565,400	1,514,300	1,369,200	1,522,300
China:[e]					
Primary	1,700,000	1,920,000	2,110,000	2,500,000	2,650,000
Secondary	540,000	700,000	800,000	870,000	800,000
Total	2,240,000	2,620,000	2,910,000	3,370,000	3,450,000
Congo (Kinshasa), primary, electrowon	10,000	10,000 [e]	1,800	--	--
Finland:					
Primary	175,216 [r]	162,300 [r]	141,000 [r]	172,354	137,710
Secondary[e]	2,000	2,000	2,000	2,000	2,000
Total	177,216 [r]	164,300 [r]	143,000 [r]	174,354	139,710
Germany:					
Primary	257,200	273,800	270,200	295,000	251,100 [p]
Secondary	251,400	266,300	273,400	293,300	282,700 [p]
Total	508,600	540,100	543,600	588,300	533,800 [p]
India:					
Primary	486,600	610,000	700,000	651,000	705,100
Secondary[e]	38,000	15,000	15,000	11,000	10,000
Total	524,600	625,000	715,000	662,000	715,100
Indonesia, primary	275,000 [e]	201,200	277,100	253,300 [r]	295,900
Iran, undifferentiated[e, 4]	227,000 [6]	242,000	250,000	248,000	260,000
Japan:					
Primary	1,319,247	1,409,087	1,367,310	1,366,310	1,297,943
Secondary	198,516	219,203	245,208	259,060	243,859
Total	1,517,763	1,628,290	1,612,518	1,625,370	1,541,802
Kazakhstan, undifferentiated	404,817 [r]	426,000 [e]	392,834 [r]	392,575 [r]	369,000 [e]
Korea, North, primary and secondary[e]	15,000	15,000	15,000	15,000	15,000
Korea, Republic of:					
Primary	436,600	449,200	475,000	500,000 [e]	455,000 [e]
Secondary	49,900	34,800	40,000	44,300 [e]	44,000 [e]
Total	486,500	484,000	515,000	544,300 [e]	499,000 [e]
Mexico:					
Primary	301,200	260,200	222,600 [r]	200,200	153,700
Secondary[e]	5,000	5,000	5,000	5,000	5,000
Total	306,200	265,200	227,600 [r]	205,200	158,700

See footnotes at end of table.

TABLE 21—Continued

COPPER: WORLD SMELTER PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country	2005	2006	2007	2008	2009
Namibia, primary[e, 5]	23,300	22,000	21,000	16,271 [r, 6]	16,300
Oman, primary	25,000 [e]	20,710 [r]	13,940 [r]	11,906 [r]	12,000 [e]
Pakistan, primary	18,600	23,600	18,200 [e]	17,800 [e]	17,500
Peru, primary	381,600	381,300	296,100	360,400	345,500
Philippines, primary	201,300	239,600	220,000 [r]	246,700	230,100
Poland:					
Primary	527,000	445,000	438,100	438,600 [r]	408,200
Secondary	30,000	80,000	40,000	43,900 [r]	68,800
Total	557,000	525,000	478,100	482,500 [r]	477,000
Romania, secondary[e]	-- [r]	-- [r]	-- [r]	--	--
Russia:[e]					
Primary	696,000	635,000	650,000	630,000	580,000
Secondary	262,000	312,000	290,000	235,000	220,000
Total	958,000	947,000	940,000	865,000	800,000
Serbia:[e]					
Primary	30,000 [7]	40,000 [r]	30,200 [r]	31,900 [r]	32,000
Secondary	1,000 [7]	1,000	1,000	1,000	1,000
Total	31,000 [7]	41,000 [r]	31,200 [r]	32,900 [r]	33,000
Slovakia, secondary	15,500	22,000 [e]	20,600 [e]	27,500	34,200
South Africa, primary	92,000	100,000	105,000	92,972 [r]	89,453
Spain:					
Primary	278,600	263,100	249,400	256,900	261,000
Secondary[e]	5,600	6,482 [6]	6,700	3,000	4,000
Total	284,200	269,582	256,100	259,900	265,000
Sweden:					
Primary	134,300 [r]	138,800 [r]	132,500 [r]	128,500 [r]	126,000
Secondary[e]	57,700 [r]	55,000 [r]	46,500 [r]	53,800 [r]	39,600
Total	192,000 [r]	193,800 [r]	179,000 [r]	182,300 [r]	165,600
Thailand:[e]					
Primary	28,600	1,000	5,600 [6]	--	--
Secondary	2,000	100	500	--	--
Total	30,600	1,100	6,100 [6]	--	--
Turkey, undifferentiated[e, 8]	27,600 [6]	30,000	30,000	35,000	30,000
United States, undifferentiated	523,000	501,000	617,000	574,000	597,000
Uzbekistan, undifferentiated[e]	105,000	95,000	92,000	92,000	92,000
Vietnam, primary	--	--	--	2,200 [e]	6,000 [e]
Zambia, primary	270,000	290,000	224,000	232,000 [e]	334,000
Grand total:	13,500,000 [r]	14,100,000 [r]	14,300,000	14,700,000	14,500,000
Of which					
Primary:					
Electrowon	10,000	10,000 [e]	1,800	--	--
Other	10,500,000 [r]	10,700,000 [r]	10,800,000 [r]	11,100,000 [r]	11,100,000
Secondary	1,700,000 [r]	2,000,000 [r]	2,080,000 [r]	2,170,000 [r]	2,040,000
Undifferentiated	1,300,000 [r]	1,310,000	1,400,000 [r]	1,360,000 [r]	1,360,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] This table includes total production of smelted copper metal, including low-grade cathode produced by electrowinning methods. The smelter feed maybe derived from ore, concentrates, copper precipitate or matte (primary), and (or) scrap (secondary). To the extent possible, primary and secondary output of each country is shown separately. In some cases, total smelter production is officially reported, but the distribution between primary and secondary has been estimated. Table includes data available through July 28, 2010.

[3] Copper content of nickel-copper matte exported to Norway for refining.

TABLE 21—Continued

COPPER: WORLD SMELTER PRODUCTION, BY COUNTRY[1, 2]

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[4] Data are for year beginning March 21 of that stated. Secondary production is estimated to be about 5% of total.

[5] Includes 8,000 to 10,000 metric tons per year for 2005–06 produced from imported toll concentrates.

[6] Reported figure.

[7] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[8] Secondary production is estimated to be about one-third of total.

TABLE 22

COPPER: WORLD REFINERY PRODUCTION, BY COUNTRY[1,2]

(Metric tons)

Country	2005	2006	2007	2008	2009
Argentina, secondary[e]	16,000	16,000	16,000	16,000	16,000
Australia, primary:					
Electrowon	50,900	52,400	42,000	53,000	23,000
Other	418,100	377,000	400,000	450,000	423,000
Total	469,000	429,400	442,000	503,000	446,000
Austria, secondary	72,300	72,600	81,400	106,700	96,200 [p]
Belgium:					
Primary[3]	252,900	238,000 [e]	228,500	233,100 [r]	220,600
Secondary[e]	130,000	153,000	165,600	162,700 [r]	153,100
Total	382,900	391,000 [e]	394,100	395,800 [r]	373,700
Brazil, primary	199,043	219,700	218,367	226,800 [r]	213,400
Bulgaria:[e]					
Primary	60,500	65,500 [4]	69,900	126,700 [r,4]	183,600 [4]
Secondary	3,000	3,000	5,000	13,000	13,200
Total	63,500	68,500	74,900	139,700 [r,4]	196,800 [4]
Burma, electrowon	34,500	19,500	15,100	--	3,500
Canada:					
Primary	484,123	465,000	407,000	400,000	305,296
Secondary	31,000	36,000	46,000	42,000	30,600
Total	515,123	501,000	453,000	442,000	335,896
Chile, primary:					
Electrowon	1,584,600	1,691,800	1,832,100	1,971,000 [r]	2,112,700
Other	1,239,400	1,119,500	1,104,400	1,086,600	1,159,100
Total	2,824,000	2,811,300	2,936,500	3,057,600 [r]	3,271,800
China:[e]					
Primary					
Electrowon	15,000	20,000	20,000	20,000	25,000
Other	1,850,000	2,000,000	2,280,000	2,680,000	2,750,000
Secondary	750,000	1,000,000	1,200,000	1,200,000	1,400,000
Total	2,615,000 [4]	3,020,000	3,500,000	3,900,000	4,175,000
Congo (Kinshasa), electrowon	--	--	6,784 [r]	45,821 [r]	159,000 [e]
Cyprus, electrowon	--	1,000	2,900	2,986 [r]	2,380
Egypt, secondary[e]	4,000	4,000	4,000	4,000	4,000
Finland:					
Primary	108,994 [r]	120,674 [r]	100,987 [r]	127,952 [r]	95,549
Secondary[e]	16,000	16,000	10,000	10,000	10,000
Total	124,994 [r]	136,674 [r]	110,987 [r]	137,952 [r]	105,549
Germany:					
Primary	293,812	312,092	301,702	300,470	290,200
Secondary	344,446	350,246	363,815	389,300	378,700
Total	638,258	662,338	665,517	689,770	668,900
Hungary, secondary[e]	10,000	10,000	10,000	--	--
India:					
Primary, electrolytic	477,000	614,000	698,600	654,200	705,100
Secondary[e]	20,000	15,000	15,000	15,000	10,000
Total	497,000	629,000	713,600	669,200	715,100
Indonesia, primary	262,900	217,600	277,000 [r]	254,000 [r]	289,200

See footnotes at end of table.

TABLE 22—Continued
COPPER: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2005	2006	2007	2008	2009
Iran:					
Primary:[e, 5]					
Electrowon	10,000	9,000	8,000	7,000	7,000
Other	123,100 [4]	140,000	145,000	140,000	150,000
Secondary	40,000 [4]	45,000 [4]	55,000	53,000	53,000
Total	173,100 [4]	194,000	208,000	200,000	210,000
Italy, secondary	32,200	36,400	28,600	24,200 [e]	6,500 [e]
Japan:					
Primary	1,227,528	1,342,350	1,369,814	1,328,157	1,238,012
Secondary	167,756	189,705	207,004	211,681	201,831
Total	1,395,284	1,532,055	1,576,818	1,539,838	1,439,843
Kazakhstan, primary	418,356	427,723	406,091	398,141 [r]	368,000
Korea, North, primary[e]	15,000	15,000	15,000	15,000	15,000
Korea, Republic of:					
Primary	481,566	541,492	536,467	495,925 [r]	489,701
Secondary	45,000	34,000	45,000	42,000	42,000 [e]
Total	526,566	575,492	581,467	537,925 [r]	531,701
Laos, electrowon	30,480	60,803	62,541	64,100	67,562
Mexico:					
Primary:					
Electrowon	92,675	89,076	107,000	74,500	65,700 [e]
Other	317,700	284,300	238,900	215,500	190,000 [e]
Secondary[e]	6,000	6,000	6,000	6,000	5,000
Total	416,375	379,376	351,900	296,000	260,700
Mongolia, electrowon	2,475	2,618	3,007	2,587 [r]	2,470
Norway, primary[6]	38,500	38,500 [e]	43,000	32,000	30,000
Oman, primary[e]	24,000	21,000 [r]	14,000 [r]	12,000 [r]	12,000
Peru, primary:					
Electrowon	165,530	173,871	172,118	160,078	162,800
Other	346,206	333,839	241,789 [r]	303,855	260,500
Total	511,736	507,710	413,907 [r]	463,933	423,300
Philippines, primary	172,000	181,000	160,200	173,600	175,000
Poland:					
Primary	530,000	476,100	493,200	483,000	450,700
Secondary	30,000	80,500	39,800	43,700	52,200
Total	560,000	556,600	533,000	526,700	502,900
Romania:					
Primary	18,739	18,583	15,584	10,323 [r]	15,000
Secondary[e]	2,000	3,000	3,000	3,000	3,000
Total	20,739	21,583	18,584	13,323 [r]	18,000
Russia:					
Primary	684,000	635,000	650,000	610,000	650,000 [e]
Secondary	249,000	312,000	289,000	250,000	220,000 [e]
Total	933,000	947,000	939,000	860,000	870,000 [e]
Serbia:					
Primary	30,100 [7]	40,000	30,600	32,800	33,000
Secondary[e]	1,000 [7]	1,000	1,000	1,000	1,000
Total	31,100 [7]	41,000	31,600	33,800	34,000
South Africa, primary[6]	99,439	104,052	113,166 [r]	92,972	89,451

See footnotes at end of table.

TABLE 22—Continued

COPPER: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2005	2006	2007	2008	2009
Spain:					
Primary	242,700	235,300	243,000	257,000 [r]	268,000
Secondary[e]	66,000	64,000	65,000	62,000 [r]	67,000
Total	308,700	299,300	308,000	319,000 [r]	335,000
Sweden:					
Primary	222,482 [r]	187,800	175,500	184,674	164,759
Secondary	22,000 [r]	41,200	38,500	43,100	41,000
Total	244,482 [r]	229,000	214,000	227,774	205,759
Taiwan, secondary[e]	4,000	4,500	4,500	4,500	4,500
Thailand:					
Primary	13,700 [r]	25,300 [r]	11,900 [r]	--	--
Secondary	2,100 [r]	1,750 [r]	814 [r]	438 [r]	--
Total	15,800 [r]	27,050 [r]	12,714 [r]	438 [r]	--
Turkey:[e]					
Primary	90,000	101,000	94,600 [r]	83,000 [r]	30,000
Secondary	5,000	5,000	5,000	5,000	4,000
Total	95,000	106,000	99,600 [r]	88,000 [r]	34,000
Ukraine, secondary[e]	20,000 [r]	20,000 [r]	20,000 [r]	20,000 [r]	20,000
United States:					
Primary:					
Electrowon	554,000	530,000	504,000	507,000	476,000
Other	654,000	675,000	764,000	713,000	636,000
Secondary	47,200	44,800	46,000	53,800	46,400
Total	1,260,000	1,250,000	1,310,000	1,270,000	1,160,000
Uzbekistan, primary	103,870	92,300 [e]	89,655	71,000 [r]	80,000
Vietnam, primary	--	--	--	-- [r]	6,000 [e]
Zambia, primary:[e]					
Electrowon[8]	155,000 [4]	178,000	200,000	175,000	145,400 [4]
Other	244,000	240,000	230,000	240,000	269,000 [4]
Total	399,000	418,000	430,000	415,000	414,400 [4]
Zimbabwe, primary[e]	7,000	7,000	6,798 [4]	3,072 [4]	3,000
Grand total	16,600,000 [r]	17,300,000	17,900,000 [r]	18,300,000 [r]	18,400,000
Of which:					
Primary:					
Electrowon	2,690,000	2,830,000	2,980,000	3,080,000 [r]	3,250,000
Other	11,800,000 [r]	11,900,000	12,200,000 [r]	12,400,000 [r]	12,300,000
Secondary	2,140,000	2,560,000 [r]	2,770,000 [r]	2,780,000 [r]	2,880,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] This table includes total production of refined copper whether produced by pyrometallurgical or electrolytic refining methods and whether derived from primary unrefined copper or from scrap. Copper cathode derived from electrowinning processing is also included. Table includes data available through July 28, 2010.

[3] Includes reprocessed leach cathode from Congo (Kinshasa).

[4] Reported figure.

[5] Data are for Iranian years beginning March 21 of that stated.

[6] May include secondary.

[7] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[8] Electrowon covers only high-grade electrowon cathodes reported as "finished production leach cathodes."

DIAMOND, INDUSTRIAL

By Donald W. Olson

Domestic survey data and tables were prepared by Connie Lopez, statistical assistant, and Donald W. Olson, mineral commodity specialist. The world production tables were prepared by Glenn J. Wallace, international data coordinator.

In 2009, U.S. synthetic diamond production was estimated to be 91.0 million carats with an estimated value of $65.1 million. U.S. imports of all forms of industrial diamond totaled about 247 million carats valued at almost $59.5 million, while exports totaled more than 67.0 million carats valued at almost $33.4 million. The estimated U.S. apparent consumption of all forms of industrial diamond was 305 million carats with an estimated value of $108 million.

Diamond is best known as a gemstone, but some of its unique properties make it ideal for many industrial and research applications as well. Current information on gem-grade diamond can be found in the U.S. Geological Survey (USGS) Minerals Yearbook, volume I, Metals and Minerals chapter on gemstones. Diamond that does not meet gem-quality standards for clarity, color, shape, or size is used as industrial-grade diamond. Production and consumption quantities and values reported are estimated to avoid disclosing company proprietary data and still provide useful data on the overall market. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using unrounded data. The USGS does not conduct surveys of either domestic polycrystalline diamond (PCD) producers or domestic chemical vapor deposition (CVD) diamond producers for quantity or value of annual production. Also, trade and consumption quantity or value data are not available for PCD or for CVD diamond.

Diamond is the hardest known material and has the highest thermal conductivity of any material at room temperature. Diamond is more than twice as hard as its nearest competitors, cubic boron nitride and silicon nitride. Because it is the hardest substance known, diamond has been used for centuries as an abrasive in cutting, drilling, grinding, and polishing. Industrial-grade diamond continues to be used as an abrasive for many applications. Even though it has a higher unit cost, diamond has proven to be more cost-effective in many industrial processes because it cuts faster and lasts longer than alternative abrasive materials (Boucher, 1997, p. 26.6). Diamond also has chemical, electrical, optical, and thermal characteristics that make it the best material available to industry for wear- and corrosion-resistant coatings, special lenses, heat sinks in electrical circuits, wire drawing, computing, and other advanced technologies.

Both synthetic and natural diamonds have industrial uses. Synthetic industrial diamond is superior to its natural diamond counterpart because its properties can be tailored to specific applications, and it can be produced in large quantities (Boucher, 1996). For these reasons, synthetic diamond accounts for about 94% of the industrial diamond used in the United States and about 99% of the industrial diamond used in the world.

Legislation and Government Programs

There is no remaining inventory of the stockpiled industrial diamond in the National Defense Stockpile (NDS), which is managed by the Defense National Stockpile Center (DNSC), Defense Logistics Agency. The last stockpiled industrial diamond was industrial diamond stone which was completely sold during 2008 (Lough, 2008). At the present time, there are no plans to stockpile any inventory of industrial diamond in the NDS.

Production

The USGS conducts an annual survey of domestic industrial diamond producers and U.S. firms that recover diamond wastes. Although most of these companies responded to the 2009 survey, one of the three industrial diamond recycling firms did not report data that they deemed to be proprietary. To protect the proprietary data of other producers and recyclers, only estimates of U.S. primary and secondary output are provided in this review.

As one of the world's leading producers of synthetic industrial diamond, the United States accounted for an estimated output of 91 million carats valued at more than $65.1 million in 2009. U.S. synthetic industrial diamond output estimates have been revised downward for 2005 through 2008 in table 6 because production data for one company had been improperly overestimated during those years. Only two U.S. companies produced synthetic industrial diamond during the year—Diamond Innovations, Inc., Worthington, OH, and Mypodiamond, Inc., Smithfield, PA.

In 2009, at least eight U.S. companies also manufactured PCD from synthetic diamond grit and powder. These companies were Dennis Tool Co., Houston, TX; Diamond Innovations; Novatek Inc., Provo, UT; Precorp Inc., Provo; Sii MegaDiamond Inc., Provo; Tempo Technology Corp., Somerset, NJ; US Synthetic Corp., Orem, UT; and Western Diamond Products LLC, Salt Lake City, UT.

During 2009, an estimated 33.9 million carats of used industrial diamond worth about $17.2 million were recycled in the United States. Recycling firms recovered most of this material from used diamond drill bits, diamond tools, and other diamond-containing wastes. Additional diamond was recovered during the year from residues generated in the manufacture of PCD; most of this material was recovered from within the production operations of the PCD-producing companies.

The recovery and sale of industrial diamond was the principal business of three U.S. companies in 2009—Industrial Diamond

Laboratory, Inc., Bronx, NY; International Diamond Services Inc., Houston, TX; and National Research Co., Fraser, MI. In addition to these companies, other domestic firms may have recovered industrial diamond in smaller secondary operations.

There were no commercially operated diamond mines in the United States during 2009. The last commercially operated diamond mine in the United States was the Kelsey Lake diamond mine, located near Fort Collins, CO, which closed in 2002 and was fully reclaimed.

Canadian diamond mining industry success stimulated some interest in exploration for diamond deposits in areas of the United States with similar geologic settings and terrain. These areas are located in Alaska, Colorado, Minnesota, Montana, and Wyoming (Associated Press, 2002, 2004; Diamond Registry Bulletin, 2005). Although exploration and field studies have found a number of large diamond deposits, none have attracted long-term investors and been able to open a commercially feasible mine thus far.

Consumption

The United States remained the world's leading market for industrial diamond in 2009. Based on production estimates and trade data, apparent U.S. consumption of industrial diamond during the year decreased by about 44% to an estimated 305 million carats valued at $108 million. This apparent consumption was the combination of 251 million carats of diamond bort, grit, dust, and powder valued at $36.6 million and 54.6 million carats of diamond stone valued at $71.9 million. These large decreases were because of the negative impact of the economic recession on industrial sectors that consume industrial diamond.

The major consuming industries of industrial diamond in the United States during 2009 were construction, machinery manufacturing, mining services (exploration drilling for minerals, natural gas, and oil), stone cutting/polishing, and transportation systems (infrastructure and vehicles). Within these sectors, stone cutting and highway building/repair together made up the largest demand for industrial diamond. Research and high-technology uses included close-tolerance machining of ceramic parts for the aerospace industry, heat sinks in electronic circuits, lenses for laser radiation equipment, polishing of silicon wafers and disk drives, and other applications in the computer industry.

Diamond tools have numerous industrial functions. Diamond drilling bits and reaming shells are used principally for minerals, natural gas, and oil. Other applications of diamond bits and reaming shells include foundation testing, masonry drilling, and inspecting concrete. The primary uses of point diamond tools are for dressing and truing grinding wheels and for boring, cutting, finishing, and machining applications. Beveling glass for automobile windows is another application. Cutting dimension stone and cutting/grooving concrete in highway reconditioning are the main uses of diamond saws; other applications include cutting composites and forming refractory shapes for furnace linings. Very fine diamond saws are used to slice brittle metals and crystals into thin wafers for electronic and electrical devices. Diamond wire dies are essential for high-speed drawing of fine wire, especially from hard, high-strength metals and alloys. The primary uses of diamond grinding wheels include edging plate glass, grinding dies, grinding parts for optical instruments, and sharpening and shaping carbide machine tool tips.

Two types of natural diamond are used by industry—diamond stone (generally larger than 60 mesh/250 micrometers) and diamond bort (smaller, fragmented material). Diamond stone is used mainly in drill bits and reaming shells used by mining companies; it also is incorporated in single- or multiple-point diamond tools, diamond saws, diamond wheels, and diamond wire dies. Diamond bort is used for drill bits and as a loose grain abrasive for polishing. Other tools that incorporate natural diamond include bearings, engraving points, glass cutters, and surgical instruments.

Synthetic diamond grit and powder are used in diamond grinding wheels, saws, impregnated bits and tools, and as a loose abrasive for polishing. Diamond grinding wheels can be as much as 1 meter in diameter.

Loose powders made with synthetic diamond for polishing are used primarily to finish cutting tools, gemstones, jewel bearings, optical surfaces, silicon wafers, and wire-drawing dies for computer chips. Hundreds of other products made from ceramics, glass, metals, and plastics also are finished with diamond powders.

Two types of PCDs used by industry are polycrystalline diamond compacts (PDCs) and polycrystalline diamond shapes (PDSs). The use of PDCs and PDSs continues to increase for many of the applications cited above, including some of those that employ natural diamond. The use of PDCs, PDSs, and matrix-set synthetic diamond grit for drilling bits and reaming shells has increased in recent years. PDCs and PDSs are used in the manufacture of single- and multiple-point tools, and PDCs are used in a majority of the diamond wire-drawing dies.

In the early 2000s, Apollo Diamond, Inc., near Boston, MA, developed and patented a method for growing extremely pure, gem-quality diamond with flawless crystal structure by CVD. The CVD technique transforms carbon into plasma, which then is precipitated onto a substrate as diamond. CVD has been used for more than a decade to cover large surfaces with microscopic diamond crystals, but until this process was developed, no one had discovered the combination of temperature, gas composition, and pressure that resulted in the growth of a single diamond crystal. Since CVD diamond precipitates as nearly pure, almost flawless diamond, they are difficult to distinguish from natural diamond by most tests (Davis, 2003). CVD diamond's highest value, besides its use as gemstones, is as a material for advanced technological uses. CVD diamond could be used to make extremely powerful lasers; to miniaturize cellular telephones and vastly improve data storage capacity for electronic devices; to create frictionless medical replacement joints; or in coatings for cars or other devices that would not scratch or wear off. The greatest potential use for CVD diamond could be in computer technology (Maney, 2005). For diamond to be an economical material for use as a semiconductor, it must be affordably grown in large wafers. As this technology becomes more fully developed, CVD diamond could possibly be grown relatively inexpensively. Growth of CVD diamond is limited only by the size of the seed placed in the diamond growing chamber. Diamond computer chips are more durable because they can work at temperatures up to 1,000 °C, while silicon computer chips stop working at about 150 °C. This means that diamond computer chips will probably work at a much higher frequency or faster speed (Diamond Registry Bulletin, 2003).

In 2004, researchers at the Carnegie Institution of Washington's Geophysical Laboratory published a study showing that researchers grew diamond crystals by a special CVD process at very high growth rates. They were able to grow gem-sized crystals in a day—a growth rate 100 times faster than other methods used before. This is a new way of producing diamond crystals for such new applications as diamond-based electronic devices and next generation cutting tools (Willis, 2004). By early 2005, the Carnegie Institution's Geophysical Laboratory and the University of Alabama jointly had developed and patented the CVD process and apparatus to produce 10-carat, ½-inch thick single diamond crystals at very rapid growth rates (100 micrometers per hour). This faster CVD method uses microwave plasma technology and allows multiple crystals to be grown simultaneously. This size is about five times that of commercially available lab-created diamonds produced by high pressure and high temperature (HPHT) methods and other CVD techniques (Willis, 2004; Carnegie Institution of Washington, 2005; Science Blog, 2005). Both Apollo Diamond and the Carnegie Institution have noted that their diamonds produced by the CVD method are harder than natural diamonds and diamonds produced by HPHT methods.

Research at the Carnegie Institution continued improving the microwave plasma CVD method developing a process to anneal the diamonds at temperatures up to 2,000 °C using a microwave plasma at pressures below atmospheric pressure. In this process, the diamond crystals, which are originally yellow-brown if produced at very high growth rates, are turned colorless or light pink. This low-pressure/high-temperature annealing process enhances the optical properties of this rapid-grown CVD single crystal diamond, and the size of the crystals that can be treated is not limited. This process is thought to produce better synthetic diamonds for high pressure devices and window materials with improved optical properties in the ultraviolet to infrared range. These high-quality, single-crystal diamonds likely will have a wide variety of applications, such as using the diamond crystals as anvils in high-pressure research, or optical uses that take advantage of the outstanding transparency of diamond. Another application might be in quantum computing, by utilizing vacancy centers in the diamond's crystal lattice for storing quantum information (Carnegie Institution for Science, 2008).

Prices

Natural and synthetic industrial diamonds differ significantly in price. Natural industrial diamond normally has a more limited range of values. The price varies from an average of $1 per carat for bort size material to about $2.50 to $10 per carat for most stones, with some larger stones selling for up to $200 per carat.

Synthetic industrial diamond has a much wider price range than natural diamond. Prices of synthetic diamond vary according to particle strength, size, shape, crystallinity, and the absence or presence of metal coatings. In general, the prices for synthetic diamond dust, grit, and powder used in grinding and polishing range from as low as $0.26 to $1.70 per carat. Strong and blocky material for sawing and drilling sells for $1.00 to $3.50 per carat. Large synthetic crystals with excellent structure for specific applications sell for many hundreds of dollars per carat (Law-West, 2002, p. 23.8).

Foreign Trade

The United States continued to lead the world in industrial diamond trade in 2009; imports were received from 35 countries, exports were sent to 42 countries, and reexports were sent to 35 countries (tables 1–4). Although the United States has been a major producer of synthetic diamond for decades, expanding domestic markets have become more reliant on foreign sources of industrial diamond in recent years. U.S. markets for natural industrial diamond have always been dependent on imports and secondary recovery operations because there has been no domestic production of natural diamond.

During 2009, U.S. imports of industrial-quality diamond stones (natural and synthetic) decreased by 56% from those of 2008 to about 1.4 million carats valued at about $18.7 million (table 1). The average value of these industrial-quality diamond stone imports was $13.30 per carat. Imports of diamond dust, grit, and powder (natural and synthetic) decreased by 50% from those of 2008 to 246 million carats valued at about $40.8 million (table 2). The average value of these industrial diamond dust, grit, and powder imports was $0.17 per carat.

Reexports account for a significant portion of total exports/reexports; therefore, exports and reexports are listed separately in tables 3 and 4 so that U.S. trade and consumption can be calculated more accurately. During 2009, there were no U.S. exports of industrial diamond stones, compared with exports of 4,000 carats valued at $47,000 for 2008. U.S. reexports of industrial diamond stone decreased by 26% from those of 2008 to 947,000 carats valued at $17.5 million and an average value of $18.50 per carat (table 3). U.S. exports of industrial diamond dust, grit, and powder (natural and synthetic) decreased by 42% from those of 2008 to 67 million carats valued at $33.4 million and an average value of $0.50 per carat. Reexports of industrial diamond dust, grit, and powder (natural and synthetic) increased by 16% from those of 2008 to 9.89 million carats valued at $4.24 million and an average value of $0.43 per carat (table 4).

World Industry Structure

In 2009, industrial diamond was produced in 30 countries (tables 5, 6). Total industrial diamond output worldwide was estimated by the USGS to be about 4.4 billion carats valued between $1.65 and $2.50 billion. Natural industrial diamond production worldwide was estimated to be more than 55 million carats, a 19% decrease compared with that of 2008. Russia was the leading producing country, followed by Congo (Kinshasa) and Australia, in descending order of quantity. These three countries produced more than 73% of the world's natural industrial diamond (table 5). Synthetic industrial diamond production worldwide was estimated to be more than 4.4 billion carats, a slight decrease compared with that of 2008. China was the leading producing country, followed by the United States, Russia, Ireland, and South Africa, in descending order of quantity. These five countries produced about 98% of the world's synthetic industrial diamond (table 6).

In addition to the countries listed in table 6, Germany and the Republic of Korea produced synthetic diamond, but specific data on their output could not be confirmed. In 2009, 97% of the total global natural and synthetic industrial diamond output was produced in China, Ireland, Russia, South Africa, and the United States. Synthetic diamond accounted for more than 99% of global diamond production and consumption.

World Review

Global diamond production decreased 17% during 2009 to 129 million carats (Mct). The world's leading rough diamond producers in decreasing order of quantity produced were: Russia, producing 32.8 Mct or 25% of total world production; Botswana, with 31.0 Mct or 24%; Congo (Kinshasa), producing 18.0 Mct or 14%; Canada, with 10.9 Mct or 9%; Australia, with 10.8 Mct or 8%; Angola, with 9.0 Mct or 7%; South Africa, with 5.5 Mct or 4%; and other countries, with 10.7 Mct or 8% (table 5). As the global recession deepened during the first quarter of 2009, many of the world's alluvial mines closed, and many exploration projects were suspended or severely reduced. De Beers Group, ALROSA Co. Ltd., and BHP Billiton were the three leading diamond exploring companies; they accounted for 64% of the estimated $393 million total global diamond exploration budget by 113 companies in 2009 (Metals Economics Group, 2010, p. 12–13; 2011, p. 10–13).

Worldwide in 2009, three small diamond mines and two expansion projects started up. Three of the startups were in Russia, and two were in Guinea (Metals Economics Group, 2010, p. 14).

Canada.— Canadian diamond production was more than 10.9 Mct with an estimated value of $1.7 billion during 2009, a decrease of about 26% compared with that of 2008. Diamond exploration continued in Canada, with several commercial diamond projects and additional discoveries in Alberta, British Columbia, the Northwest Territories, Nunavut, Ontario, and Quebec. In 2009, Canada produced 8.8% of the world's combined natural gemstone and industrial diamond output.

The Ekati Diamond Mine, Canada's first operating commercial diamond mine, completed its 11th full year of production in 2009. Ekati produced 4.2 Mct of diamond from 5.10 million metric tons (Mt) of ore. BHP Billiton Ltd. has an 80% controlling ownership in Ekati, which is in the Northwest Territories. Ekati has estimated remaining reserves of 38.5 Mt of ore in kimberlite pipes that contain 18.3 Mct of diamond. BHP Billiton projected the remaining mine life to be 13 years. Approximately 21% of the Ekati 2008 diamond production is industrial-grade material (BHP Billiton Ltd., 2010, p. 10; Perron, 2011, p. 1).

The Diavik Diamond Mine, Canada's second diamond mine, also located in the Northwest Territories, completed its seventh full year of production. In 2009, Diavik produced 5.6 Mct of diamond, a decrease of 40% from the previous year's production. This lower production was a consequence of a reduced operating level at the mine intended to balance production with lower market demand that resulted from the downturn in the economy that began in mid-2008. Diavik reacted by temporarily ceasing diamond production at the Diavik Mine between July 14 and August 24, 2009. During this time period, the Diavik Mine was placed on a care-and-maintenance schedule. At yearend 2009, Diavik estimated the mine's remaining proven and probable reserves to be 19.7 Mt of ore in kimberlite pipes containing 59.1 Mct of diamond and projected the total mine life to be 16 to 22 years. During 2009, Diavik began developing an underground mine, and construction on the underground project was substantially completed during 2009. First ore was expected during the first quarter of 2010, with full production expected in 2013. The mine is an unincorporated joint venture between Diavik Diamond Mine Inc. (60%) and Harry Winston Diamond Mines Ltd. (40%) (Diavik Diamond Mine Inc., 2010; Perron, 2011, p. 2).

Canada's third diamond mine, the Jericho Diamond Mine, is located in Nunavut and was owned by Tahera Diamond Corp. Tahera estimated the Jericho Diamond Mine's reserves to be about 5.5 Mt of ore grading 0.85 carats per ton. The Jericho Diamond Mine experienced startup problems related to ore mining and processing. The mine also has suffered financial problems owing to the cost of transporting supplies to the mine site, higher operational costs, higher oil prices, and appreciation of the Canadian dollar versus the U.S. dollar. All of these problems combined to force the company to enter into protection under Canada's "Companies' Creditors Arrangement Act" on January 16, 2008, and the mine suspended production on February 6, 2008. As a result, the mine's 2008 production was only 118,000 carats. At yearend 2009, the Tahera was finalizing arrangements to sell all its Jericho mine assets (Perron, 2011, p. 2).

The Snap Lake Mine, which is wholly owned by De Beers Canada Inc., is in the Northwest Territories. The Snap Lake deposit is a tabular-shaped kimberlite dike rather than the typical kimberlite pipe. The dike is 2.7 meters thick and dips at an angle of 15°. The deposit was mined using a modified room and pillar underground mining method in 2009. The Snap Lake Mine started mining operations in October 2007, reached commercial production levels in the first quarter of 2008, and officially opened June 25, 2008. The mine was expected to produce 1.4 million carats per year of diamond, and the mine life was expected to be about 20 years. De Beers suspended production for 6 weeks in July and August 2009. This production suspension was scheduled to align production levels with market demand. The mine's production for the year amounted to 440,000 carats for a recovered grade of 1.25 carats per ton (Perron, 2011, p. 2, 3).

The Victor Mine, which also is wholly owned by De Beers Canada, is in northern Ontario on the James Bay coast. The Victor kimberlite consists of two pipes with surface area of 15 hectares (37.1 acres). The Victor Mine initiated mining operations at the end of December 2007 and was officially opened on July 26, 2008. The Victor reportedly has 27.4 Mt of ore with average ore grade of 0.23 carats per ton estimated minable reserves. At full capacity, the open pit mine was expected to produce 600,000 carats per year, and the mine life was expected to be about 12 years. De Beers suspended mine production for 6 weeks in July and August 2009 to align production with market demand. In 2009, the mine's production was 696,000 carats valued at $244 million and had an average recovery grade of 0.33 carats per ton (Perron, 2011, p. 3).

Guinea.—The Mandala alluvial mine, owned by Stellar Diamonds, was producing with positive cash flow at 60% of capacity by yearend 2009. During 2010, the mine's output was expected to be 140,000 carats. Stellar estimated that the deposit contains 536,000 carats of diamond in 1.41 Mt of resources, grading 0.38 carats per ton (Metals Economics Group, 2010, p. 14–15).

Another alluvial mine, Bomboko, owned by West African Diamonds, had ramped up to production of 1,500 carats of diamond from 35,000 tons of resources per month by October 2009. Visual inspection of stones produced indicated that about 60% was gem quality and 40% was industrial grade. West African estimated that the deposit contains 750,000 carats of diamonds in 25 Mt of resources grading 0.03 carats per ton (Metals Economics Group, 2010, p. 14–15).

Russia.—In 2009, Russia was again the world's leading producer of combined natural gemstone and industrial diamonds as it has been every year since 2004. Russian natural diamond production was 32.8 Mct with an estimated value of $2.34 billion, a decrease of about 11% compared with that of 2008 (Metals Economics Group, 2011, p. 12).

The largest mine that came online in 2009 was the underground development of the Arkangelskaya pipe at the Lomonosov Mine in northwestern Russia. Lomonosov started mining the Arkangelskaya pipe in September at 1 million metric tons per year (Mt/yr) of ore and was estimated to have an optimum production capacity of 4 Mt/yr of ore. Lomonosov is 95% owned by Alrosa and 5% by the Government of Russia. Lomonosov was estimated to have 27.3 Mct of diamonds contained in 54.8 Mt of ore, grading at an estimated 0.5 carats per ton. The estimated mine life was 17 years, with materials coming from the Arkangelskaya and Karpinskogo-1 pipes (Metals Economics Group, 2010, p. 14–15).

The Mirny Division of Alrosa in Yakutia officially opened the Mir underground mine in August. The Mir was expected to yield 500,000 carats of diamonds from 1 Mt/yr of ore during a projected 50-year mine life. Alrosa had future plans for two additional underground operations parallel to Mir, which would provide an additional 4.5 Mt of ore (Metals Economics Group, 2010, p. 14–15).

A third new mine owned by Alrosa was the Aikhal underground mine in Yakutia. Aikhal began commercial production in December 2009. The mine reportedly was estimated to contain 1.25 Mct of diamonds in 12.5 Mt of ore grading 0.10 carats per ton. Aikhal had an estimated 25-year mine life (Metals Economics Group, 2010, p. 14–15).

Outlook

China is expected to remain the world's leading producer of synthetic industrial diamond, with annual production exceeding 4 billion carats. The United States is likely to continue to be one of the world's leading markets for industrial diamond into the next decade and likely will remain a significant producer and exporter of synthetic industrial diamond as well. U.S. industrial diamond production, imports, and apparent consumption will continue to increase as manufacturing sectors that use industrial diamond recover from the negative impact of the economic recession that started in mid-2008. U.S. demand for industrial diamond is likely to continue in the construction sector as the United States continues building and repairing the Nation's highway system.

Diamond offers many advantages for precision machining and longer tool life. In fact, even the use of wear-resistant diamond coatings to increase the life of materials that compete with diamond is a rapidly growing application. Increased tool life not only leads to lower costs per unit of output but also means fewer tool changes and longer production runs (Advanced Materials & Processes, 1998). In view of the many advantages that come from increased tool life and reports that diamond film surfaces can increase durability by a factor of 50, much wider use of diamond as an engineering material is expected.

PCD for abrasive tools and wear parts will continue to replace competing materials in many industrial applications by providing closer tolerances as well as extending tool life. For example, PDCs and PDSs will continue to displace natural diamond stone and tungsten carbide products used in the drilling and tooling industries.

CVD technology can produce extremely pure diamond crystals that will have great potential in computer technology in the production of diamond computer chips when their cost becomes competitive. These diamond computer chips will work at a much higher frequency or faster speed and can be placed in a higher-temperature environment than the silicon chips currently used in computers. Eventually, they may replace silicon chips in computers. CVD diamonds, annealed using the low-pressure/high-temperature microwave plasma process, may have applications such as using the diamond crystals in high-pressure research, optical applications that take advantage of the outstanding transparency of diamond, or using them in quantum computing to store quantum information in vacancy centers in the diamond's crystal lattice.

Truing and dressing applications will remain a major domestic end use for natural industrial diamond stone. Stones for these applications have not yet been manufactured economically. No shortage of the stone is anticipated, however, because new mines and more producers selling in the rough diamond market will maintain ample supplies. More competition introduced by the additional sources also may temper price increases.

Demand for synthetic diamond bort, grit, and dust and powder is expected to remain greater than for natural diamond material. Constant-dollar prices of synthetic diamond products probably will continue to decline as production technology becomes more cost effective; the decline is even more likely if competition from low-cost producers in China and Russia continues to increase.

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TABLE 1

U.S. IMPORTS FOR CONSUMPTION OF INDUSTRIAL DIAMOND STONES, BY COUNTRY[1]

(Thousand carats and thousand dollars)

Country	Natural industrial diamond stones[2]				Miners' diamond, natural and synthetic[3]			
	2008		2009		2008		2009	
	Quantity	Value[4]	Quantity	Value[4]	Quantity	Value[4]	Quantity	Value[4]
Australia	90	506	52	390	4	64	(5)	40
Belgium	79	452	9	164	--	--	(5)	30
Botswana	1,210	21,500	678	10,400	100	443	3	13
Congo (Kinshasa)	12	73	10	209	1	8	--	--
Ghana	3	43	(5)	5	--	--	--	--
India	116	187	40	39	74	665	11	146
Namibia	193	1,320	129	856	1	6	1	6
Russia	213	3,020	137	2,140	--	--	--	--
South Africa	1,050	6,790	295	3,540	16	255	7	118
Other	50 r	1,080	30	466	6	5,090	(5)	71
Total	3,010 r	34,900	1,380	18,200	202	6,540	22	423

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes glazers' and engravers' diamond unset, Harmonized Tariff Schedule of the United States (HTS) codes 7102.21.3000 and 7102.21.4000.

[3] HTS codes 7102.21.1010 and 7102.21.1020.

[4] Customs value.

[5] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 2

U.S. IMPORTS FOR CONSUMPTION OF DIAMOND DUST, GRIT, AND POWDER, BY COUNTRY[1]

(Thousand carats and thousand dollars)

	Synthetic[2]				Natural[2]			
	2008		2009		2008		2009	
Country	Quantity	Value[3]	Quantity	Value[3]	Quantity	Value[3]	Quantity	Value[3]
Belgium	2,110	724	709	297	166	94	20	12
China	319,000	22,100	174,000	13,500	188	142	142	65
Germany	162	89	64	34	10	2	--	--
Hong Kong	507	246	504	157	--	--	--	--
India	1,510	898	759	384	1,260	907	744	442
Ireland	96,100	33,300	44,900	17,900	2,720	1,540	637	359
Israel	10	7	--	--	11	4	--	--
Italy	7	5	9	2	1	2	--	--
Japan	2,680	1,910	1,670	922	119	49	16	46
Korea, Republic of	28,700	4,710	7,850	1,790	34	13	4	7
Macau	338	42	13	9	--	--	--	--
Mexico	225	162	--	--	38	29	--	--
Romania	1,260	192	1,240	265	3 r	11	--	--
Russia	25,500	3,130	7,700	1,470	123	122	15	17
Switzerland	1,080	1,530	1,000	1,360	446	688	231	135
Taiwan	153	24	61	15	25	4	--	--
Ukraine	326	48	327	29	--	--	--	--
United Arab Emirates	10	6	--	--	9	7	--	--
United Kingdom	4,900	1,520	1,790	761	671	455	886	478
Other	695	370	170	140	198	338	147	201
Total	486,000	71,000	243,000	39,100	6,010	4,410	2,840	1,760

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States codes 7105.10.0020, 7105.10.0030, and 7105.10.0050 for synthetic and 7105.10.0011 and 7105.10.0015 for natural.

[3] Customs value.

Source: U.S. Census Bureau.

TABLE 3

U.S. EXPORTS AND REEXPORTS OF INDUSTRIAL DIAMOND STONES, BY COUNTRY[1]

(Thousand carats and thousand dollars)

	Industrial unworked diamonds[2]			
	2008		2009	
Country	Quantity	Value[3]	Quantity	Value[3]
Exports:				
Brazil	1	33	--	--
Canada	3	13	--	--
Total	4	47	--	--
Reexports:				
Belgium	697	10,200	341	4,720
Brazil	39	276	12	87
Canada	95	924	95	670
Germany	23	645	11	326
Hong Kong	96	1,930	114	1,690
Israel	8	119	131	1,140
Japan	160	9,140	92	4,390
Korea, Republic of	15	1,020	17	860
South Africa	18	101	14	10
United Arab Emirates	1	40	16	517
United Kingdom	100	3,230	67	2,270
Other	24	333	38	814
Total	1,280	27,900	947	17,500
Grand total	1,280	28,000	947	17,500

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States code 7102.21.0000.

[3] Customs value.

Source: U.S. Census Bureau.

TABLE 4

U.S. EXPORTS AND REEXPORTS OF INDUSTRIAL DIAMOND DUST, GRIT, AND POWDER, BY COUNTRY[1]

(Thousand carats and thousand dollars)

	Synthetic[2]				Natural[2]			
	2008		2009		2008		2009	
Country	Quantity	Value[3]	Quantity	Value[3]	Quantity	Value[3]	Quantity	Value[3]
Exports:								
Austria	1,010	340	470	207	62	81	--	--
Belgium	402	104	253	61	24	8	15	6
Brazil	5,540	2,530	3,260	1,080	--	--	11	5
Canada	4,570	3,320	2,950	1,970	408	1,010	191	440
Germany	1,640	588	1,600	524	207	107	22	20
Greece	393	80	255	45	13	8	--	--
Hong Kong	326	226	15	11	14	37	36	107
India	2,070	1,070	2,410	998	157	32	59	44
Ireland	34,700	12,500	16,000	5,660	211	281	47	76
Israel	50	9	4	5	1	3	--	--
Italy	5,540	1,910	4,010	1,350	64	42	--	--
Japan	19,000	8,790	10,100	4,970	14	22	23	58
Korea, Republic of	12,200	6,320	6,010	3,550	417	216	20	14
Mexico	576	244	216	76	450	311	259	125
Singapore	578	732	745	1,660	43	114	14	42
Spain	58	11	199	44	--	--	--	--
Switzerland	8,460	7,010	6,580	4,820	479	279	205	124
Taiwan	3,270	1,180	2,340	982	112	45	27	17
Thailand	5,560	2,800	3,880	1,280	18	9	4	3
United Kingdom	2,230	821	2,460	819	412	530	212	202
Other	4,260	1,780	1,810	975	469	1,060 [r]	369	998
Total	112,000	52,400	65,500	31,100	3,580	4,200	1,510	2,280
Reexports:								
Belgium	127	91 [r]	74	33	264	457	81	192
Brazil	377	180 [r]	557	117	2	7	--	--
Canada	2,730	1,840	2,180	1,220	127	195 [r]	24	81
Germany	79	94	10	22	7	20 [r]	11	32
India	--	--	48	15	--	--	--	--
Ireland	1,480	754	825	467	2	7	18	14
Italy	140	38	--	--	--	--	--	--
Japan	1,940	503 [r]	3,560	1,340	11	33	--	--
Korea, Republic of	365	173	373	83	--	--	--	--
Mexico	107	104	157	56	23	42	20	45
United Kingdom	152	104 [r]	115	73	183	147	7	13
Other	369	224 [r]	1,830	437	40 [r]	54	4	4
Total	7,860 [r]	4,100	9,720	3,860	659 [r]	962 [r]	165	381
Grand total	120,000	56,500	75,200	34,900	4,230	5,160	1,680	2,660

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States codes 7105.10.0025 for synthetic and 7105.10.0010 for natural.

[3] Customs value.

Source: U.S. Census Bureau.

TABLE 5
NATURAL DIAMOND: WORLD PRODUCTION, BY COUNTRY AND TYPE[1, 2, 3]

(Thousand carats)

Country and type[4]	2005	2006	2007	2008	2009
Gemstones:					
Angola	6,371	8,258	8,732	8,016 [r]	8,100
Australia	8,577	7,305	231	273	60 [e]
Botswana[e]	23,900	24,000	25,000	25,000	24,000
Brazil[e]	208	181	182	182 [r]	182 [5]
Canada	12,314	13,278	17,144	14,803	10,946
Central African Republic[e]	300	340	370	302 [r]	300
China[e]	100	100	100	100	100
Congo (Kinshasa)	7,000	5,800 [r]	5,700 [r]	4,200 [r]	3,600
Côte d'Ivoire[e]	210	210	210	210	210
Ghana	810	780	720 [e]	520 [e]	500 [e]
Guinea	440	380	815	2,500	2,400
Guyana	357	341	269	169 [r]	179
Lesotho	52	231	454	450 [e]	450 [e]
Namibia	1,902	2,400	2,266 [r]	2,435 [r]	2,300
Russia[e]	23,000	23,400	23,300	21,925 [5]	17,791 [5]
Sierra Leone	401 [r]	362 [r]	362 [r]	223 [r]	200 [e]
South Africa[e]	6,400	6,100	6,100	5,200	2,400
Tanzania[e]	185	230	239	202 [r]	150
Venezuela[e]	46	45	45	45	45
Zimbabwe[e]	160	160	100	100	100
Other[6]	109	70	65	105 [r]	126
Total	92,800	94,000 [r]	92,400 [r]	87,000	74,100
Industrial:					
Angola[e]	708	918	970	900	900
Australia	25,730	21,915	18,960	15,397 [r]	10,700
Botswana[e]	8,000	8,000	8,000	8,000	7,000
Brazil[e]	600	600	600	600	600
Central African Republic[e]	80	85	93	75 [r]	60
China[e]	960	965	970	1,000	1,000
Congo (Kinshasa)	28,200	23,100 [r]	22,600 [r]	16,700 [r]	14,400
Côte d'Ivoire[e]	90	90	90	90	90
Ghana[e]	200	190	180	130 [r]	120
Guinea	100	95	200	600	600 [e]
Russia[e]	15,000	15,000	15,000	15,000	15,000
Sierra Leone	267 [r]	241 [r]	241 [r]	149 [r]	100 [e]
South Africa[e]	9,400	9,100	9,100	7,700	3,100
Tanzania[e]	35	42	44	31 [r]	27
Venezuela[e]	69	70	70	70	70
Zimbabwe[e]	900	900 [r]	600 [r]	700 [r]	700
Other[7]	94	67	72	115 [r]	140
Total	90,400	81,400 [r]	77,800 [r]	67,300 [r]	54,600
Grand total	183,000	175,000 [r]	170,000 [r]	154,000 [r]	129,000

[e] Estimated. [r] Revised.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 19, 2010.

[3] In addition to the countries listed, Nigeria and the Republic of Korea produce natural diamond and synthetic diamond, respectively, but information is inadequate to formulate reliable estimates of output levels.

[4] Includes near-gem and cheap-gem qualities.

[5] Reported figure.

[6] Includes Cameroon, Congo (Brazzaville), Gabon (unspecified), India, Indonesia, Liberia, and Togo (unspecified).

[7] Includes Congo (Brazzaville), India, Indonesia, and Liberia.

TABLE 6

SYNTHETIC DIAMOND: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2, 3]

(Thousand carats)

Country	2005	2006	2007	2008	2009
Belarus	25,000	25,000	25,000	25,000	25,000
China	3,800,000	3,900,000	4,000,000	4,000,000	4,000,000
Czech Republic	5	5	5	5	5
France	3,000	3,000	3,000	3,000	3,000
Ireland	60,000	60,000	60,000	60,000	60,000
Japan	34,000	34,000	34,000	34,000	34,000
Russia	80,000	80,000	80,000	80,000	80,000
South Africa	60,000	60,000	60,000	60,000	60,000
Sweden	20,000	20,000	20,000	20,000	20,000
Ukraine	8,000	8,000	8,000	8,000	8,000
United States	126,000 r	128,000 r	130,000 r	131,000 r	91,000 [4]
Total	4,220,000 r	4,320,000 r	4,420,000 r	4,420,000 r	4,380,000

[r] Revised.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 19, 2010.

[3] In addition to the countries listed, Germany and the Republic of Korea also produces significant amounts of synthetic diamond, but output is not officially reported, and available information is inadequate to formulate reliable estimates of output levels.

[4] Reported figure.

DIATOMITE

By Robert D. Crangle, Jr.

Domestic survey data and tables were prepared by Elsie D. Isaac, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

Production of diatomite in the United States decreased by 25% to 575,000 metric tons (t), with a corresponding decrease in value of $171 million free on board (f.o.b.) plant in 2009 compared with 764,000 t valued at $147 million f.o.b. plant in 2008 (table 1). The United States remained the world's leading producer and consumer of diatomite.

Diatomite used for filtration represented 55% of consumption, followed by its use as a cement additive (24%), an absorbent (10%), a filler (9%), and an insulation constituent (2%). Other diatomite applications, including abrasives, insecticides, and soil conditioner, accounted for the remainder (table 2). Major diatomite products were sold as various grades of calcined powders.

Encroachment into diatomite markets by natural and synthetic substitute material remained minimal, particularly for beverage filtration. Use as a biological filter for human blood plasma continued to increase.

Diatomite is a chalk-like, soft, friable, earthy, very fine-grained, siliceous sedimentary rock comprised of fossilized diatom remains. Diatomite often has a light color (white if pure, commonly buff to gray in situ, and rarely black). It is extremely lightweight because of its low density and high porosity, and essentially chemically inert. Diatomaceous earth (often abbreviated as D.E.) is a common alternate name but is more appropriate for the unconsolidated or less lithified sediment. Diatomite is also known as kieselguhr (Germany), tripolite (after an occurrence near Tripoli, Libya), and moler (an impure Danish form). Alfred Nobel named his explosive invention "dynamite" following his discovery that nitroglycerin could be stabilized if first absorbed in diatomite (Nobel, 1868).

Diatomite deposits form from an accumulation of amorphous hydrous silica cell walls of dead diatoms in both oceanic and fresh waters. These microscopic single-cell aquatic plants (algae) contain an internal, elaborate siliceous skeleton consisting of two frustules (valves) that vary in size from less than 1 micrometer (µm) to more than 1 millimeter in diameter but are typically 10 to 200 µm in diameter. The frustules have a broad variety of delicate, lacy, perforated shapes, including cylinders, discs, feathers, ladders, needles, and spheres. Additional information on the environmental and physical properties of diatoms can be found in Dolley and Moyle (2003) and Moyle and Dolley (2003). The oldest occurrences of diatomite are thought to be of Cretaceous age, deposited about 66 million to 138 million years ago. Older diatomite occurrences may have been altered into other forms of silica, particularly chert, owing to diagenesis, burial, and exposure. Detailed information on the geology of diatomite can be found in Wallace (2003) and Moyle and Dolley (2003).

Domestic Data Coverage

Domestic production data for diatomite were developed by the U.S. Geological Survey (USGS) from a voluntary annual survey of U.S. diatomite-producing sites and company operations. The USGS canvass for 2009 covered 7 diatomite-producing companies with 12 mining areas and 9 processing facilities. All companies responded, accounting for 100% of the production listed in table 1. Some company data were not complete and were estimated on the basis of annual hours worked, as reported by the Mine Safety Health Administration. Data were rounded to no more than three significant figures. All percentages in this report were computed based on unrounded data.

Production

In 2009, 575,000 t of diatomite was produced from 12 separate mining areas and 9 processing facilities in California, Nevada, Oregon, and Washington. Major producers were Celite Corp. (a subsidiary of Imerys USA, Inc.) with mines and facilities in California, Nevada, and Washington, and EP Minerals, LLC (a subsidiary of EaglePicher Corp.) with operations in Nevada and Oregon. California was the leading producing State, followed by Nevada. The combined output of these two States accounted for about 85% of U.S. production in 2009.

Because diatomite occurrences are at or near the earth's surface, recovery from most deposits is achieved through low-cost, open pit mining. Outside the United States, however, underground mining is fairly common owing to deposit location and topographic constraints. Explosives are generally not required for surficial or subsurface mining because of the soft, friable nature of the deposits. In Iceland, dredging is used to recover lake-bottom diatomaceous mud deposits.

Diatomite is often processed near the mine to reduce transportation costs associated with the crude ore, which can contain up to 65% water. Processing typically involves a series of crushing, drying, size-reduction, and calcining operations, using heated air for conveying and classifying within the plant. Fine-sized diatomite grains, especially from baghouses, are used most often for filler-grade products, while coarser particles are employed for filtration purposes. In the latter processing stages, calcining is performed in rotary kilns to affect chemical and physical changes.

Diatomite production costs for the United States average 10% for mining, 60% to 70% for processing, and 20% to 30% for packing and shipping. Energy costs compose a large and growing portion (25% to 30%) of diatomite production costs, both in the direct costs of mining and transportation, as well as within the energy-intensive calcining process. Diatomite used for cement production does not normally require calcining, and the reported unit value is considerably lower. For 2009, overall diatomite production was lower as a result of the economic downturn and its negative impact on the construction industry, a large consumer of diatomite.

Consumption

Apparent domestic consumption of diatomite in 2009 was approximately 488,000 t, a decrease of approximately 21% from 616,000 t in 2008. The total domestic and export quantity of filter-grade diatomite sold or used by U.S. producers was 320,000 t in 2009, a decrease of 12% from 365,000 t in 2008, accounting for 56% of total diatomite sold or used. Diatomite remains the dominant filtration medium with estimates suggesting it represents 65% of the total filtration market (Moores, 2008). Diatomaceous earth used in cement manufacture accounted for 136,000 t, or 24%, of total diatomite production in 2009, a decrease of 46% from 254,000 t, or 33% of the 2008 production.

Use of diatomite as a filler was 53,000 t in 2009, a decrease of 16% from the 63,000 t in 2008, which accounted for 9% of total diatomite sold or used. For absorbents, 56,000 t of diatomite was reported, a decrease of 20% from 70,000 t in 2008, accounting for 10% of total diatomite sold or used. Diatomite use for insulation decreased by 17% to 10,000 t in 2009 from 12,000 t in 2008, accounting for 2% of total diatomite sold or used.

In antiquity, diatomite was used by the Greeks as an abrasive and in the production of lightweight building bricks and blocks. In the late 1800s, diatomite became of industrial interest in Western Europe when pulverized diatomite was the preferred absorbent and stabilizer of nitroglycerine used to make dynamite. Maryland was the site of the first U.S. production of diatomite in 1884. By the late 1880s, very pure, huge deposits near Lompoc, CA, became the focus of interest and have continued to dominate world markets (Dolley and Moyle, 2003). While diatomite is principally used as a filtration medium, other uses include those of a silica additive in cement and various other compounds, a filler in a variety of products from paints to dry chemicals, an absorbent for industrial spills and pet litter, an insulation medium in sawn and molded shapes and loose granules, a mild abrasive in polishes, and an agent in the purification and extraction of DNA.

Commercial diatomite products provide fine-sized, irregular-shaped, porous noncaking particles that have a large surface area and high liquid-absorption capacity. They are relatively chemically inert, have a low refractive index, are mildly abrasive, have a low thermal conductivity with a reasonably high fusion point, can be slightly pozzolanic, are very high in silica, and can be produced and delivered at a cost consistent with customer applications. Sawn shapes, which continue to account for a significant part of world diatomite production, have long been used as lightweight building material, especially in China, and primarily for thermal insulation (especially the high-clay-content Danish moler). Both dried natural products and calcined products are used in building applications.

The major use of diatomite continues to be as a filtration medium for beverages (especially beer and wine), sugar and sweetener liquors, oils and fats, petroleum and chemical processing (including reprocessing waste dry cleaning fluids), pharmaceuticals, and water (industrial process, potable, swimming pool, and waste). Another leading use is as an absorbent for industrial spills (oil and toxic liquids) and for pet litter.

Another important broad category of use is as a filler, often serving a dual purpose, such as an extender and flatting agent in paints and coatings; a bulking and anticaking agent in granular materials; and as a multieffect component in plastics (including preventing films from sticking). Other filler uses are as an extender and absorbent carrier for catalysts, dry pesticides, pharmaceuticals, and other chemicals. Other significant uses are as an insulation material in bulk (loose) and molded forms, and as a silica additive in various compounds, including mortar and portland cement, where its pozzolanic properties are utilized.

Commercial diatomite products are offered in a great variety of grades. Principal grading factors are the size, shape, overall arrangement, and proportions of the various types of frustules (factors that affect filtration rate, product clarity, and absorption capacity). Other factors include silica content, impurity levels (especially iron), and the presence of clay, sand, and organics. Brightness, whiteness, and abrasive hardness are considered for specialized diatomite applications. Free-crystalline silica content, although normally low, is required to be identified, particularly for calcined products. Calcining removes organics, increases filtration rate, oxidizes iron, increases specific gravity, increases particle hardness, and can lighten color. Flux-calcining significantly affects the physical and chemical properties and makes a white product. Most filter grades are calcined.

Prices

The calculated weighted average unit value of diatomite sold or used by U.S. producers during 2009, using USGS survey data and estimates, was $255 per metric ton f.o.b. plant, an increase of about 14% compared with about $224 per ton in 2008 (table 3). The average values for filtration decreased slightly in 2009 to about $375 per ton from $380 per ton reported in 2008. The value for diatomite used for absorbent purposes was unchanged at $41 per ton. The unit value for material used as fillers increased slightly to $421 per ton in 2009, while insulation remained unchanged at $50 per ton in 2009. The average value for specialized or other uses in 2009 decreased by 45% to $1,960 per ton from $3,600 per ton in 2008. This decrease was derived from a specialty-grade form of diatomite, which is subject to large price fluctuations, and represented less than 1% of total U.S production in 2009.

Foreign Trade

Export and import data presented here from the U.S. Census Bureau may be of limited accuracy. This is a result of reporting inconsistencies from producers and a lack of detail for various materials, one of which includes diatomite, specified in the 2009 Harmonized Tariff Schedule of the United States (HTS) issued by the U.S. International Trade Commission. Exports of diatomite from the United States in 2009 were approximately

88,000 t, about 63,000 t less than in 2008 (table 4). Exports accounted for about 15% of total domestic production sold or used. The trade data were issued under heading 2512 of the HTS, described as applying to siliceous fossils, including kieselguhr, tripolite, diatomite, and similar siliceous earths of an apparent specific gravity of 1 or less. Industry sources, however, indicated that exports also included some flux-calcined material, which is included under code 3802.90.2000, where it is not differentiated from activated clays. Similarly, heat-insulating mixtures and sawn and molded unfired shapes of diatomite are collected under data classification code 6806.90.0090 and are not exclusively identified as diatomite. Lastly, fired, sawn, and molded shapes of diatomite are covered under heading 6901, which is not exclusively used for diatomite data.

According to the U.S. Census Bureau data, diatomite and diatomite products were exported to 142 countries in 2009, with 25 countries accounting for 87% of the total. The main export markets were Canada (18,668 t), Germany (11,669 t), Belgium (6,175 t), Japan (4,257 t), Australia (3,964 t), Thailand (2,750 t), Taiwan (2,548 t), Vietnam (2,525 t), Russia (2,460 t), and Korea (2,102 t). These 10 countries accounted for 65% of the total exports reported. Based on available trade data from the U.S. International Trade Commission, the average unit value free alongside ship of exported diatomite was $467 per ton in 2009 compared with $448 per ton in 2008, an increase of 4% (table 4). Import data for diatomite show that 1,257 t came from 24 countries in 2009. Italy was the leading source with 448 t (36%), Mexico with 422 t (34%), the Netherlands with 206 t (16%), France with 57 t (5%), and Australia with 41 t (3%). These five countries provided 93% of the imports to the United States in 2009.

World Review

The estimated world production of diatomite in 2009 was 1.87 Mt (table 5). World reserves are thought to be almost 1 billion metric tons (Gt), which is more than 500 times the current annual estimated world production rate of 1.87 Mt. About 250 Mt, or 25% of the estimated 1 Gt of world reserves, is in the United States (Crangle, 2010). The world reserve base was estimated by the U.S. Bureau of Mines in 1985 to be almost 2 Gt (Meisinger, 1985). The world's reputed largest producing district in terms of volume is near Lompoc, CA. A resource assessment of this location suggests these deposits could singularly meet the world's current diatomite consumption for hundreds of years. Estimating data regarding reserve calculations can be challenging because some data are proprietary and not released by companies and countries. Huge deposits, on the order of at least 110 Mt of reserves, occur in China (Lu, 1998, p. 53; Crangle, 2010).

The five leading diatomite producers in 2009 were, in decreasing order of production, the United States, China, Denmark, Mexico, and Japan. The United States continued to be the leading producer, consumer, and exporter of diatomite, and accounted for 31% of total world production, followed by China with 24%, Denmark with 12% (all moler products), and Mexico and Japan, each with 6%. Smaller amounts of diatomite were mined in 22 additional countries.

Outlook

Despite the economic downturn in 2009 and a decrease in overall production, diatomite prices increased from those in 2008. The economic stability of the mineral commodity was largely owing to its use as a filtration medium, where its demand remains strong, particularly in the filtration of human blood plasma and other biotechnical applications. Likewise, the encroachment of more advanced filter applications, including carbon membranes, ceramics, and polymers, were not a concern in 2009. The high costs associated with these alternatives and a cultural preference toward the use of diatomite in the brewing and wine industries indicate a strong likelihood for the continued and widespread use of diatomite in filtration. A prolonged economic recession, however, could lead to further production declines.

The associated issue of free-crystalline silica, particularly after diatomite is calcined, was expected to continue to be a concern, especially in the filler and absorbent markets. Although some diatomite deposits were reported to be low in free-crystalline silica, an effort to classify diatomite and related absorbent products as free of this material remains contentious, litigious, and, to date, unsuccessful. The use of uncalcined diatomite has replaced its calcined counterpart in some markets. Adequate supplies of diatomite, owing to the large domestic and world reserves, coupled with small or no changes in demand, will probably remain available for the foreseeable future.

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TABLE 1
DIATOMITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES[1]

(Thousand metric tons and thousand dollars)

	2008	2009
Domestic production, sales:		
Quantity	764	575
Value	171,000	147,000

[1] Data are rounded to no more than three significant digits.

TABLE 2
DIATOMITE SOLD OR USED, BY MAJOR USE[1]

(Percentage of U.S. production)

	2008	2009
Absorbents	9	10
Cement[2]	33	24
Fillers	8	9
Filtration	48	55
Insulation	2	2
Other[3]	(4)	(4)

[1] Includes exports.

[2] As ingredient in portland cement.

[3] Includes abrasives, lightweight aggregates, and unspecified uses.

[4] Less than ½ unit.

TABLE 3
AVERAGE VALUE PER METRIC TON OF DIATOMITE, BY MAJOR USE[1]

	2008	2009
Absorbents	41	41
Cement[2]	9	7
Fillers	412	421
Filtration	380	375
Insulation	50	50
Other[3]	3,600	1,960
Weighted average	224	255

[1] Rounded estimates.

[2] As ingredient in portland cement.

[3] Includes abrasives, lightweight aggregates, and unspecified uses.

TABLE 4
U.S. EXPORTS OF DIATOMITE[1, 2]

(Thousand metric tons and thousand dollars)

Year	Quantity	Value[3]
2008	151	67,700
2009	88	41,100

[1] Harmonized Tariff System (HTS) heading 2512.00.0000, natural and straight-calcined grades, but in practice probably includes an undetermined quantity of flux-calcined product HTS heading 3806.90.2000.

[2] Data are rounded to no more than three significant digits.

[3] Free alongside ship value.

Source: U.S. Census Bureau.

TABLE 5

DIATOMITE: ESTIMATED WORLD PRODUCTION, BY COUNTRY [1, 2]

(Thousand metric tons)

Country	2005	2006	2007	2008	2009
Algeria	2 [3]	2	2 [3]	2	2
Argentina	34 [3]	39 [3]	50 [3]	37 [r, 3]	40
Australia	20	20	20	20	20
Brazil, marketable	8	9 [3]	6 [3]	6 [r, 3]	6 [p]
Chile	16 [3]	19 [3]	25 [3]	25 [r, 3]	20
China	410	420	420	440	440
Colombia	-- [r]	-- [r]	-- [r]	-- [r]	--
Commonwealth of Independent States[4]	80	80	80	80	80
Costa Rica	1 [r, 3]	3 [r, 3]	4 [r, 3]	4 [r, 3]	4
Czech Republic	38	53	19	31 [r]	--
Denmark[5]	234	235	230	230	225
Ethiopia[6]	(7) [3]	-- [r, 3]	-- [r]	-- [r]	--
France	75	75	75	75	75
Germany	2 [r]	2 [r]	2 [r]	2 [r]	2
Iceland	29	28	28	28	26
Iran[8]	1	2	(7) [r]	(7) [r]	(7)
Italy	25	25	25	25	25
Japan	130 [r, 3]	130	120	115	110
Kenya	(7) [3]	(7)	(7) [r, 3]	(7) [r, 3]	(7)
Korea, Republic of	2 [3]	3 [3]	2 [3]	3 [r, 3]	3
Macedonia	5	5	5	5	5
Mexico	62 [3]	63 [3]	63 [3]	83 [3]	116 [3]
Mozambique	1 [r]	1 [r]	1 [r, 3]	(7) [r, 3]	(7)
Peru	35	35	22 [r, 3]	12 [r, 3]	10 [3]
Poland	1	1	1	1	1
Portugal	(7)	(7)	(7)	(7)	(7)
Romania	1 [3]	2 [3]	2 [r]	-- [r]	--
Spain[9]	44 [r]	52 [r]	50 [r]	50 [r]	50
Thailand	1 [3]	1 [3]	1 [3]	4 [r, 3]	2
Turkey	44 [3]	45 [3]	33 [3]	30	30
United States[10]	653 [3]	799 [3]	687 [3]	764 [3]	575 [3]
Total	1,960 [r]	2,150 [r]	1,970 [r]	2,070 [r]	1,870

[p] Preliminary. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown. Purity and moisture content are generally not reported or estimated.

[2] Table includes data available through March 29, 2010.

[3] Reported figure.

[4] Information is inadequate for formulation of reliable estimates for individual countries.

[5] Data represent "extracted moler" (reported cubic meters times 1.5). Contains about 30% clay.

[6] Year ending July 7 of that stated.

[7] Less than ½ unit.

[8] Data are for Iranian years beginning March 21 of that stated.

[9] Includes tripoli.

[10] Sold or used by producers.

EXPLOSIVES

By Lori E. Apodaca

In 2009, U.S. explosives consumption was 2.26 million metric tons (Mt), about a 34% decrease from that of 2008; sales of explosives were reported in all States except Delaware. Coal mining, with 70% of total consumption, continued to be the dominant use for explosives in the United States. Wyoming, West Virginia, and Kentucky, in descending order, led the Nation in coal production, accounting for 63% of the total. These States were also the leading explosives-consuming States, accounting for 45% of total U.S. explosives sales.

Legislation and Government Programs

In November, the U.S. House of Representatives passed the Chemical Facility Anti-Terrorism Act of 2009 (H.R. 2868). The bill would permanently authorize and expand the Chemical Facility Anti-Terrorism Standards (CFATS) that took effect in 2007 and expired in the fall of 2009 (Green Markets, 2009). CFATS 2009 also included two controversial features—the Inherently Safer Technologies provision for facilities in high-risk categories, which authorizes the Department of Homeland Security to designate any chemical substance as a substance of concern and establish threshold quantities for each chemical that is used, stored, manufactured, processed, or distributed by a chemical facility and a citizen enforcement, which would allow lawsuits by citizens against the facilities that violate the Act.

The National Fire Protection Association (NFPA) revised its code relating to explosives and ammonium nitrate. The NFPA combined code NFPA 490 (code for the storage of ammonium nitrate) with NFPA 400 (code for hazardous materials). NFPA 400 included several documents related to hazardous materials and did not change any of the information on ammonium nitrate that was part of NFPA 490 (Nitrogen + Syngas, 2009a).

Production

Sales of ammonium-nitrate-based explosives (blasting agents and oxidizers) were 2.24 Mt, which was about a 34% decrease from those in 2008, and accounted for about 99% of U.S. industrial explosives sales. Sales of permissibles (explosives approved for use in gassy and dusty environments) were about 34% higher than those in 2008, and sales of other high explosives decreased by 34% (table 1).

Companies contributing data to this report, that are members of the Institute of Makers of Explosives (IME), are as follows:

Accurate Energetic Systems, LLC
Austin Powder Co.
Baker Atlas (a division of Baker Hughes Inc.)
Davey Bickford USA, Inc.
Douglas Explosives, Inc.
Dyno Nobel Inc.
GEODynamics, Inc.
Jet Research Center (a division of Halliburton Co.)
Maine Drilling & Blasting Inc.
Maxam North America, Inc.
Nelson Brothers Inc.
Orica USA Inc.
Owen Oil Tools LP (a division of Core Laboratories N.V.)
Senex Explosives Inc.
Titan Specialties Ltd.
Vet's Explosives Inc.
Viking Explosives and Supply Inc.
W.A. Murphy, Inc.

Incitec Pivot Ltd. announced it would cease production of ammonium nitrate in early 2010 at its Battle Mountain, NV, site. The site would continue to be used as a warehousing and distribution facility for ammonium nitrate. Battle Mountain's plant had a 130,000-metric-ton-per-year (t/yr) ammonium nitrate production capacity (Nitrogen + Syngas, 2010a).

Consumption

The principal application for explosives in the United States was coal mining, accounting for 70% of the total explosives sales for consumption (table 2). In 2009, U.S. coal production decreased to 973 million metric tons, according to preliminary data from the U.S. Energy Information Administration (EIA) (Freme, 2010, p. 1). Coal production decreased in the Appalachian and western regions by 13% and 7.7%, respectively, compared with production in 2008. In the interior region, coal production remained about the same (Freme, 2010, p. 5). Three States (Wyoming, West Virginia, and Kentucky), in descending order, led the Nation in coal production, accounting for 63% of the total. These States were also the leading explosives-consuming States.

Construction, the second ranked consuming industry, accounted for 10% of total explosives sales; quarrying and nonmetal mining, 9%; metal mining, 8%; and miscellaneous uses, 3%. Wyoming, West Virginia, Kentucky, Indiana, Virginia, Alabama, and Pennsylvania were, in descending order, the leading consuming States (greater than 90,000 metric tons sold), with a combined total of 67% of U.S. sales (table 3).

The dollar value of new construction (residential and nonresidential) put in place in 2009 decreased by 15% compared with that in 2008 (U.S. Census Bureau, 2010). Based on monthly data, the seasonally adjusted industry growth rate from 2008 to 2009 for metal mining was -13.4%, and the growth rate for quarrying and nonmetallic mineral mining was -17.8% (Federal Reserve Board, 2010).

Classification of Industrial Explosives and Blasting Agents.—Apparent consumption of commercial explosives used for industrial purposes in this report is defined as sales as reported to the IME. Commercial explosives imported for industrial uses were also included in sales. The principal distinction between high explosives and blasting agents is their sensitivity to initiation. High explosives are cap sensitive, whereas blasting agents are not. Black powder sales were minor and were last reported in 1971. The production classifications used in this report are those adopted by the IME.

***High Explosives.*—Permissibles.**—The Mine Safety and Health Administration (MSHA) approved grades by brand name as originally established by the National Institute for Occupational Safety and Health (NIOSH) testing.

Other High Explosives.—These include all high explosives except permissibles.

Blasting Agents and Oxidizers.—These include ammonium nitrate-fuel oil (ANFO) mixtures, regardless of density; slurries, water gels, or emulsions; ANFO blends containing slurries, water gels, or emulsions; and ammonium nitrate in prilled, grained, or liquor (water solution) form. Bulk and packaged forms of these materials are contained in this category. In 2009, about 93% of the total blasting agents and oxidizers sales was in bulk form.

World Review

Australia.—In February, Incitec Pivot announced that the construction of the A$935 million Moranbah ammonium nitrate plant in Central Queensland was put on hold for at least a year as the demand for explosive products had fallen. The Moranbah project is a 330,000 t/yr fully integrated ammonium nitrate complex that was about 25% complete when the project was stopped (Australian Broadcasting Corporation, 2009).

CSBP Ltd. announced the approval of an engineering and design study to increase ammonium nitrate production capacity at its Kwinana industrial complex, 40 kilometers south of Perth, Western Australia. The project was anticipated to increase the ammonium nitrate production capacity by 260,000 t/yr, bringing CSBP's overall ammonium nitrate capacity to 780,000 t/yr. Cost estimates for the expansion were $417 to $463 million (Fertilizer Week, 2009).

In December, Orica Ltd. of Australia received approval from the Australian Government to expand its Kooragang Island nitrogen complex. The project was expected to include the expansion of the existing ammonia plant and the installation of a new nitric acid plant and ammonium nitrate plant. The proposed expansion would increase the ammonium nitrate capacity to approximately 750,000 t/yr from 430,000 t/yr (Orica Ltd., 2009).

Canada.— Incitec Pivot announced it would end ammonium nitrate production at its Maitland, Ontario, plant in early 2010. The site was expected to continue to be used as a warehousing and distribution facility for ammonium nitrate. Maitland had an 189,000-t/yr ammonium nitrate capacity (Nitrogen + Syngas, 2010a).

India.—Deepak Fertilisers and Petrochemicals Corp. Ltd. began work on the new 300,000-t/yr low-density ammonium nitrate plant at the company's Taloja site in Maharashtra. Deepak originally had planned to locate the new facility in Orissa but opted to expand the existing site after failing to acquire land for this project. The new unit was scheduled for completion by November 2010 (Nitrogen + Syngas, 2009b).

Indonesia.—In June, the State-owned construction company PT Rekayasa signed a contract with PT Kaltim Nitrate Indonesia (KNI) (a joint venture between PT Armindo Group and Orica Ltd. of Australia) to build the largest ammonium nitrate plant in southeast Asia at a cost of $173 million. The plant was scheduled to be built in Bontang, East Kalimantan, and would have a capacity of 300,000 t/yr. The plant was expected to be completed in the second quarter of 2011 (Jakarta Post, 2009).

PT Multi Nitro Kimia (a part of PT Ancora Indonesia Resources) planned to expand its industrial-grade ammonium nitrate production to 130,000 t/yr from 37,000 t/yr by 2011 (Nitrogen + Syngas, 2010b).

Outlook

According to the EIA, U.S. coal production was expected to decrease by less than 1% in 2010 compared with that in 2009 in response to high coal inventories. In 2011, production was projected to increase by about 3.6% compared with that in 2010 to meet continued growth in coal consumption (U.S. Department of Energy, Energy Information Administration, 2010, p. 7). Based on the coal production projections, explosives consumption was expected to remain about the same in 2010 as in 2009 and increase slightly in 2011.

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TABLE 1

SALIENT STATISTICS OF INDUSTRIAL EXPLOSIVES AND BLASTING AGENTS SOLD FOR CONSUMPTION IN THE UNITED STATES[1]

(Metric tons)

Class	2008	2009
Permissibles	1,200	1,610
Other high explosives	35,800	23,700
Blasting agents and oxidizers	3,380,000	2,240,000
Total	3,420,000	2,270,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: Institute of Makers of Explosives.

TABLE 2

ESTIMATED INDUSTRIAL EXPLOSIVES AND BLASTING AGENTS SOLD FOR CONSUMPTION IN THE UNITED STATES, BY CLASS AND USE[1, 2]

(Thousand metric tons)

Class	Coal mining	Quarrying and nonmetal mining	Metal mining	Construction work	All other purposes	Total
2008:						
Permissibles	1	(3)	(3)	(3)	--	1
Other high explosives	5	13	2	15	1	36
Blasting agents and oxidizers	2,340	332	273	359	76	3,380
Total	2,350	345	275	374	77	3,420
2009:						
Permissibles	2	(3)	(3)	(3)	--	2
Other high explosives	3	8	1	10	1	24
Blasting agents and oxidizers	1,580	201	175	225	56	2,240
Total	1,590	209	176	235	57	2,270

-- Zero.

[1] Distribution of industrial explosives and blasting agents by consuming industry estimated from indices of industrial production and economies as reported by the U.S. Department of Energy, the Federal Reserve Board, the U.S. Department of Transportation, and the U.S. Census Bureau.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Less than ½ unit.

TABLE 3

INDUSTRIAL EXPLOSIVES AND BLASTING AGENTS SOLD FOR CONSUMPTION IN THE UNITED STATES, BY STATE AND CLASS[1]

(Metric tons)

	2008				2009			
	Fixed high explosives		Blasting agents		Fixed high explosives		Blasting agents	
State	Permissibles	Other	and oxidizers	Total	Permissibles	Other	and oxidizers	Total
Alabama	25	301	87,300	87,600	14	257	95,900	96,200
Alaska	--	1,130	26,800	27,900	--	528	16,020	16,500
Arizona	54	7,220	75,300	82,600	39	119	25,500	25,700
Arkansas	--	259	16,000	16,300	--	123	15,800	15,900
California	--	441	35,600	36,000	15	539	20,500	21,100
Colorado	12	699	29,600	30,300	18	659	23,400	24,100
Connecticut	--	251	6,900	7,150	24	274	6,460	6,760
Delaware	--	--	--	--	--	--	--	--
Florida	--	160	35,700	35,900	--	93	28,300	28,400
Georgia	--	454	35,800	36,300	--	254	23,800	24,100
Hawaii	--	--	355	355	--	0	680	680
Idaho	--	54	43,900	44,000	--	151	9,510	9,660
Illinois	10	416	38,400	38,800	--	324	32,400	32,700
Indiana	--	975	187,000	188,000	70	980	189,000	190,000
Iowa	--	699	25,300	26,000	111	422	14,200	14,700
Kansas	--	138	19,800	19,900	--	119	6,640	6,760
Kentucky	308	2,010	386,000	388,000	206	1,330	292,000	293,000
Louisiana	--	628	3,180	3,800	--	571	4,010	4,580
Maine	--	123	2,970	3,100	--	183	3,620	3,800
Maryland[2]	10	179	16,800	17,000	--	272	9,750	10,000
Massachusetts	15	155	5,640	5,810	79	119	4,790	4,990
Michigan	--	135	39,800	40,000	--	125	23,700	23,800
Minnesota	--	149	85,800	86,000	--	56	16,600	16,700
Mississippi	--	38	69	107	--	18	5	22
Missouri	4	1,980	68,200	70,200	333	2,040	53,400	55,700
Montana	--	1,880	73,500	75,400	--	2,010	55,200	57,200
Nebraska	--	82	8,250	8,330	--	74	1,780	1,860
Nevada	--	1,480	140,000	142,000	29	1,220	21,600	22,800
New Hampshire	--	321	11,500	11,800	--	756	13,400	14,100
New Jersey	--	60	6,020	6,080	--	138	1,890	2,030
New Mexico	(3)	297	45,900	46,200	1	330	22,400	22,700
New York	(3)	901	17,400	18,300	8	734	5,640	6,380
North Carolina	--	631	27,100	27,700	--	575	20,400	21,000
North Dakota	--	24	2,800	2,800	--	11	2,650	2,660
Ohio	--	1,180	60,400	61,600	--	362	41,900	42,300
Oklahoma	--	283	34,900	35,200	--	140	19,600	19,700
Oregon	--	1,460	14,300	15,800	--	111	4,700	4,810
Pennsylvania	64	1,290	102,000	103,000	36	1,390	90,400	91,800
Rhode Island	--	27	852	880	--	25	914	939
South Carolina	--	137	9,460	9,600	--	205	4,970	5,170
South Dakota	--	57	5,510	5,570	--	54	4,380	4,430
Tennessee	(3)	1,200	36,400	37,600	--	1,420	28,000	29,400
Texas	(3)	1,470	118,000	119,000	18	699	62,700	63,500
Utah	19	321	94,800	95,100	43	219	64,100	64,400
Vermont	3	92	1,770	1,860	4	196	1,480	1,680
Virginia	348	945	166,000	167,000	299	1,560	114,000	116,000
Washington	34	802	22,000	22,800	53	670	7,950	8,670
West Virginia	290	1,240	423,000	425,000	154	758	348,000	349,000
Wisconsin	6	496	11,900	12,400	30	231	7,620	7,880
Wyoming	--	517	675,000	676,000	29	240	377,000	378,000
Total	1,200	35,800	3,380,000	3,420,000	1,610	23,700	2,240,000	2,270,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes the District of Columbia.

[3] Less than ½ unit.

Source: Institute of Makers of Explosives.

FELDSPAR AND NEPHELINE SYENITE

By Lori E. Apodaca and Arnold O. Tanner

Domestic survey data and tables were prepared by Raymond I. Eldridge, III, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2009, feldspar production in the United States decreased to 550,000 metric tons (t), valued at about $36 million, from 650,000 t produced in 2008, valued at $40 million, based upon a combination of reported and estimated U.S. Geological Survey (USGS) data. Exports of feldspar decreased by 49% to 7,520 t valued at $1.15 million, and imports of feldspar increased by 5% to 2,120 t valued at $646,000. Imports of nepheline syenite (predominantly from Canada) decreased by 4% to 308,000 t valued at about $37 million. World production of feldspar was about 20 million metric tons (Mt) (table 1).

Feldspar was mined and produced in seven States. Apparent consumption of feldspar and imported nepheline syenite combined was about 850,000 t, primarily for use in the glass and ceramics industries and also as fillers in various products such as paints and coatings. Data on feldspar includes that of aplite (one U.S. producer), a rock in which quartz and feldspar (potassium and sodic plagioclase) are the dominant minerals. Nepheline syenite was produced in one State but was consumed for use as roofing granules and in other construction applications. Trade data in this report are from the U.S. Census Bureau.

Feldspar

Production.—Feldspar was mined, in descending order of estimated output, in North Carolina, Virginia, California, Idaho, Oklahoma, Georgia, and South Dakota. North Carolina accounted for about 38% of the total. Data on domestic production and sales and use of feldspar in this report are based upon data collected by the USGS by means of a voluntary survey. Nine companies mined feldspar and operated 12 beneficiation facilities—4 in North Carolina, 3 in California, and 1 in each of the 5 remaining States (table 3). Of these 12 beneficiation facilities, 8 responded to the canvass, representing about 70% of the 2009 production tonnages listed in tables 1 and 2, comparable with that of 2008. Production for the remaining operations was estimated from prior-year production levels.

Consumption.—Feldspar is used in glassmaking, ceramics, and to some extent as a filler and extender in paint, plastics, and rubber. Of the domestic feldspar sold or used, an estimated two-thirds by tonnage went into the manufacture of glass, including glass containers and glass fiber. In glassmaking, feldspar fluxes the system—lowering the melting temperature and helping promote the mixing of the melt components. The alumina from feldspar improves product hardness, durability, and resistance to chemical corrosion. In ceramics, the alkalis in feldspar (calcium, potassium, and sodium ions) act as a flux, lowering the melting temperature of a mixture as in glassmaking. Feldspar melts at an early stage in the firing process, forming a glassy phase or matrix in which the alkali ions help to lower the melting temperature and soften the small crystalline and glassy components of the system and promote an increased fusing of the same (Roskill Information Services Ltd., 2008, p. 200). Pottery (including electrical insulators, sanitaryware, tableware, and tile) and other uses, such as fillers, accounted for the remainder of the feldspar consumed (table 4). The value of total feldspar sold or used in table 4 is higher than the feldspar production value listed in tables 1 and 2 because table 4 values represent the final marketed feldspar products.

The U.S. Census Bureau discontinued container glass reports in 2008, and authoritative data are no longer publicly available. Feldspar consumption in container glass probably declined in 2009 because of continued declines in the U.S. economy.

Other feldspar uses included glass fiber for home insulation, sanitaryware, and tile. Because new U.S. housing starts of 570,000 were 37% lower than in 2008, feldspar consumption in these applications decreased (U.S. Census Bureau, 2010). In 2009, U.S. tile consumption decreased overall by 14%, but shipments of domestic tile increased by 10% from those of 2008, indicating a corresponding increase of feldspar consumption for that end use. In 2009, domestic shipments of tile totaled nearly 50 million square meters, approximately the same level as in 2007 (Tile Council of North America, Inc., 2010).

World Review.—Feldspar was produced in more than 50 countries, with significant and potentially economic deposits of feldspar occurring in at least 70 countries (table 7). Italy was the leading producing country with an estimated 4.7 Mt of feldspar in 2009, followed by Turkey, with an estimated 4.2 Mt. China's production was estimated to be about 2 Mt. World production decreased by an estimated 3 Mt to 19.8 Mt (table 7).

Recovery for feldspar's two major consumer industries, glass and ceramics, from the generally worldwide economic recession of 2008 and early 2009, was slow in 2009. In Europe and North America, there was a general decrease in glass consumption. Alternative packaging from competing materials in some market segments and a recent trend toward importation of less expensive containers from China were factors causing this decline. In 2009, the leading producers of glass containers in France, Germany, Italy, Spain, and the United Kingdom decreased glass production. Germany, Europe's leading producer, saw its output decline to 3.8 Mt in 2009 from 4.1 Mt in 2008. Flat glass production used in construction, however, increased in some rapidly growing economies, including Brazil, China, and India (Feytis, 2010a).

In 2008, the world ceramic tile industry experienced its first real slowdown in growth in more than a decade owing to its close links with the building construction industry; sluggish growth in the industry continued in 2009. In 2008 and early 2009, ceramic tile production levels, sales, and exports in dominant manufacturing countries such as China, Italy, and

Spain were lower than previously expected. China's ceramic tile export growth slowed because of the economic downturn's effects in Europe and the United States, which were important international customers for China's ceramic tile. Less affected were Brazil and India, whose ceramic industries depend more on domestic consumption than on exports. Increases in those two countries' construction projects resulted in increased domestic sales of ceramic tiles. India's ceramic tile industry has neither a large export nor import component. Brazil's ceramic tile industry has a more significant export component, which decreased by 20% in 2008 and by 25% in 2009 (Maynard, 2010).

Italy.—Italy was the world's leading feldspar producer in 2009; most of its output was used in the country's ceramics industry. Italy also exported about 142,000 t of feldspar in 2009 and imported about 1.6 Mt, largely from Turkey (United Nations Statistics Division, undated a). Italy's ceramic tile production decreased by 30% in volume, and its sales volumes decreased by 19.4% in 2009 compared with those of 2008 as a result of the downturn in the world economy. In 2009, exports declined by nearly 20%, the largest decreases taking place in the first 9 months of the year for shipments to Russia and the United States, which decreased by 46% and 39%, respectively (O'Driscoll, 2009b).

Saudi Arabia.—A shortage in affordable housing and a growing need for more schools and hospitals were driving opportunities for growth in Saudi Arabia's construction industry. Several leading ceramic companies in the country were developing new mines and plants and were expanding existing ones. The country's ceramic tile industry planned to increase use of local raw materials with the exception of some specialized materials required for products such as white porcelain tile and white sanitaryware. Flat glass producers supplying the new housing market would also draw from these local sources (O'Driscoll, 2009c). Development was underway for one new feldspar project in southern Saudi Arabia.

Turkey.—Ranked as the world's second leading feldspar producer, Turkey exported about 2.9 Mt of feldspar (United Nations Statistics Division, undated a). Feldspar was mined in the southeast part of the country and exported to major ceramic manufacturing countries throughout Europe.

Nepheline Syenite

Production.—No nepheline syenite was produced in the United States for ceramic, glass, or filler use. However, in Arkansas, nepheline syenite with a high iron content was produced for use in roofing granules, road materials, asphalt and concrete aggregate, and related products. Estimated total production of Arkansas nepheline syenite used for nonaggregate applications was 520,000 t in 2008, but published estimates for 2009 were not available (Rogers, 2009).

Consumption.—In glass and ceramics manufacture, nepheline syenite, like feldspar, provides alkalis that act as a flux. In glass, nepheline syenite also supplies alumina, imparting the same benefits as feldspar.

World Review.—Nepheline syenite, which was once only available from Canada, Norway, and Russia, is being produced in other countries as well. Nepheline syenite projects have been brought into production in Brazil, China, and Turkey for feldspathic uses. Iran was conducting a feasibility study for use of nepheline syenite in alumina production (Sutton, 2009).

Canada.—Canada's sole nepheline syenite producer, Unimin Canada, Ltd., operated two plants at its Blue Mountain and Nephton, Ontario, deposits, about 175 kilometers northeast of Toronto. Production of marketable nepheline syenite was 527,000 t in 2009 (Natural Resources Canada, 2011). Detailed end-use data have not been available in recent years, but historically, consumption has been in glass, ceramics, filler, and abrasive markets. Total Canadian nepheline syenite exports were about 366,000 t in 2009 (United Nations Statistics Division, undated b). The dominant recipient in 2009 was the United States, with 308,000 t.

Norway.—North Cape Minerals AS produced nepheline syenite from an underground mine on the arctic island of Stjernoya; output was estimated to be 350,000 t in 2009. End-use data for this material have not been available in recent years, but uses in the past included glass (including amber glass), ceramics, and fillers. In 2009, total exports from Norway were about 335,000 t, the large majority of which went to Poland, about 93,000 t; Germany, 85,000 t; Netherlands, 61,000 t; and the United Kingdom, 35,000 t (United Nations Statistics Division, undated b).

Outlook

Producers of feldspar and nepheline syenite face continuing challenges related to excess supply and increased production costs in 2010. Higher costs for reagent chemicals, natural gas, electric power, motor fuels, and regulatory compliance are expected to continue to affect production costs. In addition, higher transportation charges for shipping feldspathic products by rail and truck in 2010 are likely to increase delivered raw material costs for industrial consumers.

According to the Freedonia Group, U.S. food container demand may rise modestly during the next few years, increasing feldspar consumption by glass container manufacturers. The use of glass containers in the United States was expected to increase in future years as a result of consumer demand and Federal and State government appeal for pure, "green" (environmentally friendly), and sustainable (economic and recyclable) food and beverage packaging. The glass industry has seen a recent decrease in the use of flat glass because of declines in the automobile and construction industries; however, long-term growth is expected. As economic conditions improve, new residential construction was expected to increase in 2010 creating increased need for glass and ceramics and thus feldspar. Increased commercial and residential remodeling might result in increased demand for glass and ceramics.

Globally, ceramics industry growth significantly slowed during the recession, and with it, the use of feldspar lessened. However, it is anticipated that the ceramic industry will rebound in the next few years. The main centers of ceramic production are China, Italy, Latin America, Southeast Asia, and Spain. Although consuming much of its output internally, China is likely to continue as an important exporter of ceramic tile. Owing to an anticipated recovery in the construction sector, demand for feldspar and associated raw materials is likely to follow. Innovative ideas and products in ceramics, such as thinner and stronger ceramic sheets that can be laid over existing tiled floors without the need for removal and porcelain tiles that offer superior physical and chemical characteristics, are likely to help strengthen that sector (Feytis, 2010b). Main growth in feldspar demand is expected to be concentrated in Southeast Asia, Eastern Europe, and South America, potentially representing an average growth of about 5% annually (Roskill Information Services, Ltd., 2008, p. 310).

Fiberglass demand in the United States is forecast to increase by 3.3% per year through 2013. Growth in the industry will be driven by efforts to reduce costs and broaden markets, with best growth prospects anticipated for glass wool fiber (O'Driscoll, 2009a)

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TABLE 1

SALIENT FELDSPAR AND NEPHELINE SYENITE STATISTICS[1]

		2005	2006	2007	2008	2009
United States:						
Produced, feldspar:						
Quantity[e, 2, 3]	metric tons	750,000	760,000	730,000	650,000	550,000
Value[e, 2]	thousands	$42,700	$44,600	$43,800	$40,000 [r]	$35,600
Exports, feldspar:[4]						
Quantity	metric tons	15,200	10,400	9,980	14,600	7,520
Value[5]	thousands	$2,070	$1,930	$1,950	$2,390	$1,150
Imports for consumption[4]						
Feldspar:						
Quantity	metric tons	26,200	5,180	3,570	2,030	2,120
Value[6]	thousands	$1,700	$549	$642	$646	$646
Nepheline syenite:						
Quantity	metric tons	340,000	426,000	391,000	321,000	308,000
Value[6]	thousands	$33,800	$36,000	$38,900	$35,000	$36,800
Consumption, apparent[e, 7]	thousand metric tons	1,100	1,180	1,120	957	856
World, production[8]	do.	16,800 [r]	20,500 [r]	21,500 [r]	22,800 [r]	19,800 [e]

[e]Estimated. [r]Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits.

[2] Includes hand-cobbed feldspar, flotation-concentrate feldspar, feldspar in feldspar-quartz mixtures, and aplite; may differ from sales in table 4.

[3] Rounded to two significant digits.

[4] Source: U.S. Census Bureau.

[5] Free alongside ship (f.a.s.) value.

[6] Customs value.

[7] Production plus imports minus exports. Includes feldspar and nepheline syenite.

[8] Feldspar only.

TABLE 2

ESTIMATED FELDSPAR PRODUCTION IN THE UNITED STATES[1]

(Thousand metric tons and thousand dollars)

	Flotation concentrate		Other[2]		Total	
Year	Quantity	Value	Quantity	Value	Quantity	Value
2008	280	15,800	370	24,200	650	40,000
2009	210	13,600	340	22,000	550	35,600

[1] Quantity data are rounded to two significant digits, and value data are rounded to three signigicant digits; may not add to totals shown.

[2] Includes hand-cobbed feldspar, feldspar content of feldspar-quartz mixtures, and aplite; excludes nepheline syenite.

TABLE 3

U.S. PRODUCERS OF FELDSPAR IN 2009

Company	Location	Product
APAC-Arkansas, Inc.	Muskogee, OK	Feldspar-quartz mixture.
Feldspar Corp.,The	Monticello, GA	Potassium feldspar.
Do.	Spruce Pine, NC	Sodium-potassium feldspar.
Graniterock Co.	Felton, CA	Feldspar-quartz mixture.
Kings Mountain Minerals Inc.	Kings Mountain, NC	Do.
K-T Feldspar Corp.	Spruce Pine, NC	Sodium-potassium feldspar; feldspar-quartz mixture.
Pacer Corp.	Custer, SD	Potassium feldspar.
P.W. Gillibrand Co. Inc.	Simi Valley, CA	Feldspar-quartz mixture.
Unimin Corp.	Byron, CA	Do.
Do.	Emmett, ID	Do.
Do.	Spruce Pine, NC	Sodium-potassium feldspar.
U.S. Silica Co.	Montpelier, VA	Aplite.

Do. Ditto.

TABLE 4

ESTIMATED FELDSPAR SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1, 2]

(Thousand metric tons and thousand dollars)

	2008		2009	
Use	Quantity	Value	Quantity	Value
Glass[3]	430	26,600	360	23,200
Pottery and miscellaneous	220	16,500	200	14,400
Total	650	43,100 [4]	550	37,600 [4]

[1] Includes hand-cobbed feldspar, flotation-concentrate feldspar, feldspar in feldspar-quartz mixtures, and aplite.

[2] Quantity data are rounded to two significant digits, and value data are rounded to three significant digits; may not add to totals shown.

[3] Includes container glass, glass fiber, and other glass.

[4] Represents final marketable product; value higher than that listed for production in tables 1 and 2.

TABLE 5

U.S. EXPORTS OF FELDSPAR, BY COUNTRY[1, 2]

(Metric tons and dollars)

	2008		2009	
Country	Quantity	Value[3]	Quantity	Value[3]
Canada	1,590	370,000	880	230,000
China	261	27,600	14	13,200
Colombia	2,440	517,000	2,160	522,000
Costa Rica	2,060	275,000	231	32,200
French Polynesia	16	16,200	28	27,600
Hong Kong	--	--	24	3,010
Italy	1,040	280,000	20	5,450
Nicaragua	1,600	212,000	153	21,200
Norway	3,270	275,000	3,520	220,000
Trinidad and Tobago	107	15,600	464	70,400
Other (23 countries)	2,260	402,000	20	5,250
Total	14,600	2,390,000	7,520	1,150,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Presentation of annual data is based on the quantities (gross weight) of the 10 leading countries in 2009.

[3] Free alongside ship value.

Source: U.S. Census Bureau.

TABLE 6

U.S. IMPORTS FOR CONSUMPTION OF FELDSPAR, BY COUNTRY[1, 2, 3]

(Metric tons and dollars)

	2008		2009	
Country	Quantity	Value[4]	Quantity	Value[4]
Australia	138	43,300	3	2,340
Canada	65	206,000	--	--
Germany	224	97,300	836	371,000
Mexico	1,550	267,000	1,240	252,000
United Kingdom	23	21,200	40	19,800
Other (9 countries)	22	10,400	--	--
Total	2,030	646,000	2,120	646,000

-- Zero.

[1] Excludes nepheline syenite (mostly from Canada), which is listed in table 1.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Presentation of annual data is based on the quantities (gross weight) of the five leading countries in 2009.

[4] Customs value.

Source: U.S. Census Bureau.

TABLE 7
FELDSPAR: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009
Argentina	151,307	170,728	291,562 [r]	220,234 [r]	213,671
Australia, includes nepheline syenite[e]	50,000	50,000	50,000	50,000	50,000
Brazil, processed, marketable	122,887	77,285	171,589	170,000 [r]	150,000
Bulgaria[e]	72,867 [4]	93,091 [4]	90,000	90,000	90,000
Chile	5,820	5,847	6,704	17,834 [r]	9,079
China[e]	1,850,000	1,950,000	2,000,000	2,000,000	2,000,000
Colombia[e]	81,000	86,000	91,000	86,000 [r]	85,000
Cuba[e]	8,000	5,500	5,600	4,300 [r]	4,500
Czech Republic	472,000	487,000	514,000	488,000 [r]	431,000
Ecuador	38,250	67,844	14,308	14,000 [r, e]	10,000 [e]
Egypt	357,000 [e]	360,000 [e]	135,290 [r, 5]	407,320 [r]	353,623
Ethiopia[6]	445	478	459 [r]	424 [r]	420 [e]
Finland	60,000 [e]	56,263 [r]	55,124 [r]	NA [r]	NA
France, crude[e]	650,000	650,000	650,000	650,000	650,000
Germany	168,640	167,332	171,303	161,416 [r]	140,000 [e]
Greece[e]	95,000	95,000	95,000	62,000 [r, 4]	28,617 [4]
Guatemala	3,808	17,176	30,234	45,854 [r]	5,762
India	414,637	386,685	397,328	400,000 [e]	410,000 [e]
Iran	286,033	290,000 [e]	512,261 [r]	501,821 [r]	500,000 [e]
Italy	3,995,233	4,019,495	4,200,000 [e]	4,727,000	4,700,000 [e]
Japan, includes aplite[e]	800,000	800,000	750,000	700,000	700,000
Jordan	1,000	11,054	9,800	2,950 [r]	--
Kenya[e]	22	25	30 [r]	30 [r]	30
Korea, Republic of	508,644	427,378	398,513	344,257 [r]	622,700
Macedonia	27,076	32,824	32,814	28,920 [r]	19,377
Malaysia	117,180	142,358	358,775	457,377 [r]	356,620
Mexico	349,109	459,209	438,696	445,519 [r]	383,113 [p]
Morocco[e]	20,000	20,000	20,000	20,000	20,000
Nigeria[e]	1,700	1,700	1,700	1,700	13,631 [4]
Norway[e]	76,000	75,000	75,000	62,000 [r, 4]	48,000
Pakistan	25,032	15,085	22,000	26,000 [r]	19,000
Peru	6,000	6,010 [e]	15,450	13,063	5,006
Philippines	11,850	15,176	14,837	15,838 [r]	16,394
Poland[6]	457,400	431,300	497,900 [r]	599,100 [r]	550,000 [e]
Portugal	133,344	257,570	168,606 [r]	157,359 [r]	320,000
Romania[7]	74,920	33,100	44,897	25,974 [r]	14,317
Russia[e]	45,000	45,000	45,000	45,000	45,000
Saudi Arabia	42,000	42,300	73,000	550,000	500,000 [e]
Serbia[e]	3,500 [8]	3,500	3,500	3,500	3,500
Slovakia[e]	5,000	5,000	5,000	5,000	13,000 [4]
South Africa	57,534	75,400	90,185 [r]	105,815	101,394
Spain, includes pegmatite	650,000 [r]	674,766	680,000 [r]	690,000 [r, e]	550,000 [e]
Sri Lanka	34,000	56,864 [r]	46,583 [r]	55,212 [r]	73,365
Sweden, salable, crude and ground[e]	43,000	42,000	42,000	42,000	42,000 [e]
Thailand	1,149,717	1,067,684	684,668	670,618 [r]	600,000 [e]
Turkey	2,331,971	5,771,892	6,548,796	6,767,500 [r]	4,212,547
United Kingdom, china stone[e]	1,835 [4]	2,000	2,000	1,000	1,000
United States[9]	750,000	760,000	730,000	650,000	550,000

See footnotes at end of table.

TABLE 7—Continued
FELDSPAR: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009
Uruguay	2,150	2,470	2,500	2,500	2,500 e
Uzbekistan e	4,300	4,300	4,300	4,300	4,300
Venezuela e	202,000 [4]	200,000 [4]	200,000	200,000	200,000
Total	16,800,000 r	20,500,000 r	21,500,000 r	22,800,000 r	19,800,000

e Estimated. p Preliminary. r Revised. NA Not available. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through April 21, 2010.

[3] In addition to the countries listed, Namibia, the United Arab Emirates, and Yemen may produce feldspar, but output is not officially reported; and available information is inadequate for the formulation of reliable estimates of output levels.

[4] Reported figure.

[5] Data are for fiscal years ending July 7 of year stated.

[6] Of the amounts shown, the dedicated feldspar mine production accounts for only part of total feldspar production.

[7] Rounded to two significant digits to avoid disclosing proprietary data.

[8] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[9] Rounded to two significant digits.

FERROALLOYS

By Lisa A. Corathers, Joseph Gambogi, Peter H. Kuck, John F. Papp, Désirée E. Polyak, and Kim B. Shedd

Domestic survey data and tables were prepared by Pamela A. Wiser, statistical assistant. The world production table was prepared by Glenn J. Wallace, international data coordinator.

Ferroalloys are alloys of iron employed to add chemical elements into molten metal, usually during steelmaking. Ferroalloys impart distinctive qualities to steel and cast iron or serve important functions during production and are, therefore, closely associated with the iron and steel industry, the leading consumer of ferroalloys. The leading ferroalloy-producing countries in 2009 were, in decreasing order of production, China, South Africa, India, Kazakhstan, and Russia (table 7). These countries accounted for 83% of world ferroalloy production. World production of bulk ferroalloys—chromium, manganese, and silicon—was estimated to have been 29.4 million metric tons (Mt) in 2009, a 7% decrease compared with the revised figure of 31.5 Mt for 2008 (table 7).

Growth in most ferroalloy industries in response to China's economic growth and infrastructure development during the past few years has put strains on world mine production, ferroalloy production, and transportation facilities. South Africa, a leading ferroalloy producer, experienced electricity shortages in 2007 through 2009, which affected all ferroalloy producers in the country. India's electrical power infrastructure was challenged to the extent that ferroalloy producers in India have constructed their own electrical power generation plants to ensure electrical power supply. Coke, an essential ingredient in ferroalloy production, was also in short supply. Transportation delays were experienced in several countries owing to a shortage of rail haulage cars and port loading problems.

Eleven companies in the United States produced 8 ferroalloys at 12 plants (table 1). With the exception of ferrosilicon, production statistics for most ferroalloys were concealed to avoid disclosing company proprietary data (table 7). U.S. reported consumption of bulk ferroalloys in 2009 was approximately 0.8 Mt of manganese and silicon ferroalloys (table 3) and about 0.2 Mt of contained chromium in ferrochromium (table 4). Comparing reported consumption in 2009 with that of 2008, ferrochromium decreased by 9%, ferromanganese (including silicomanganese) decreased by 20%, and ferrosilicon decreased by 14%. The United States was a net importer of ferroalloys and ferroalloy metals in 2009. On a gross weight basis and compared with that in 2008, U.S. total ferroalloy and ferroalloy metal imports decreased by 58% and exports decreased by 14%, which resulted in a net import decrease of 61% (table 6).

Boron, chromium, cobalt, copper, molybdenum, nickel, niobium (columbium), phosphorus, silicon, titanium, tungsten, vanadium, zirconium, and the rare-earth elements are some of the other alloying elements used for the characteristics they provide to steels and cast irons (Brown and Murphy, 1985, p. 265).

Ferrochromium

The leading world chromite ore-producing countries in 2009 were India (more than 3 Mt), Kazakhstan (more than 3 Mt), and South Africa (more than 6 Mt). More than 95% of chromite ore production was smelted in electric-arc furnaces to produce ferrochromium for the metallurgical industry. The leading world ferrochromium-producing countries were China (1.6 Mt), Kazakhstan (1.1 Mt), and South Africa (2.8 Mt). India produced in excess of 0.8 Mt of ferrochromium. Most of the 7.2 Mt of ferrochromium produced was consumed in the manufacture of stainless steel. The leading stainless steel producing areas of the world—Asia (primarily China, India, Japan, Republic of Korea, and Taiwan), Europe (primarily Western Europe and Scandinavia including Belgium, Finland, France, Germany, Italy, Spain, Sweden, and the United Kingdom), and the Americas (primarily Brazil and the United States)—accounted for most of world stainless steel production. World stainless steel production exceeded 25 Mt in 2009.

In response to anticipated future demand growth, new ferrochromium-producing plants were under construction or planned in Kazakhstan and South Africa. Four industry trends were evolving—ferrochromium was being increasingly produced using environmentally friendly, energy- and recovery-efficient, prereduction, closed-furnace processes; chromium was being recovered from ferrochromium slag; the ferrochromium and stainless steel production industries were consolidating ownership; and strategic alliances between those two industries were being developed.

Factors affecting world ferrochromium supply in 2009 included electricity shortages, raw material availability, and transportation constraints. As a result, world ferrochromium production was 11% less than that of 2008. The world financial downturn of 2008 and subsequent world recession reduced the need for ferrochromium, which permitted facility development and planning to take place without the stress of material shortages.

Ferromanganese

Two manganese ferroalloys, ferromanganese and silicomanganese, are key ingredients for steelmaking. Manganese ferroalloys were produced domestically by two companies—Eramet Marietta Inc., owned by France's Eramet Group, and Felman Production Inc., owned by Ukraine's Privat Group (table 1). Despite domestic production in 2009, the United States had to import 284,000 metric tons (t) of ferromanganese and silicomanganese (gross weight). Of that amount, 78% was imported from, in decreasing order, South

Africa (146,000 t), Australia (29,356 t), Norway (25,400 t), and Georgia (20,300 t). China was the leading world producer of manganese ferroalloys, with output about 190% greater than that of the next three major producers—India, Japan, and Ukraine—combined (table 7).

Ferromolybdenum

Chile, China, and the United States accounted for about 80% of world production of molybdenite ore in 2009. Three other molybdenite ore-producing countries—Canada, Mexico, and Peru—supplied an additional 13% of world production. Molybdenite concentrates are roasted to form molybdic oxide, which can be converted into ferromolybdenum, molybdenum chemicals, or molybdenum metal. About 47% of the total reported molybdenum consumed in the United States (18,100 t) was in the form of molybdic oxides, and about 23% was consumed as ferromolybdenum. Although the United States was the second leading molybdenum-producing country in the world, it imported almost one-half of its ferromolybdenum requirements in 2009. The steel industry accounted for most of ferromolybdenum consumed in the United States in 2009, principally in the production of stainless and full alloy steels (table 4).

Ferronickel

In 2009, the major ferronickel-producing countries were, in descending order of gross weight output, Japan (285,000 t), Colombia (160,000 t), and New Caledonia (147,000 t). Together, these three countries accounted for about 60% of world production excluding China. Indonesia, Ukraine, Republic of Korea, and Macedonia, in descending order of gross weight output, all produced between 53,000 t and 63,000 t of ferronickel, accounting for 24% of world production, again excluding China. China was a special case and not included in these calculations because its industry produced large tonnages of nickel pig iron in addition to a spectrum of conventional ferronickel grades, for an estimated combined output of 600,000 t gross weight. The nickel content of individual Chinese products varied from about 1.6% to as much as 80%, depending upon customers' end use.

The Falcondo ferronickel operation in the Dominican Republic was on care-and-maintenance status during 2009 and had no production. The production loss from the Dominican Republic was more than offset by production from the new Gwangyang ferronickel smelter in the Republic of Korea. The Gwangyang smelter [a joint venture of Pohang Iron and Steel Co. Ltd. (POSCO) and Société Minière du Sud Pacifique (SMSP)] was commissioned in October 2008. The smelter was designed to process laterite ore, averaging 2.2% nickel, from SMSP's mines in New Caledonia. The Gwangyang ferronickel is produced by the rotary kiln—electric furnace process. By yearend 2009, the Korean smelter was operating close to design capacity—30,000 metric tons per year (t/yr) of nickel in shot averaging 17% to 18% nickel (Rodd and others, 2010).

Brazil had three ferronickel smelting complexes under construction at yearend 2009—Barro Alto (Anglo American plc), Goias State, Niquelandia (Grupo Votorantim), Goias State, and Onca Puma (Vale S.A.), Para State. Of the three, the Barro Alto smelter was expected to become operational first in early 2011, initially producing 18,000 t/yr of nickel in ferronickel. In the South Pacific, Xstrata plc and the SMSP Group planned to commission their Koniambo smelter near Kone, New Caledonia, in mid-2012. The Koniambo smelter would be capable of producing 60,000 t/yr of nickel in ferronickel (Xstrata plc, 2010, p. 14, 50, 82).

In the United States, the steel industry accounted for virtually all the ferronickel consumed in 2009, with more than 95% used in stainless and heat-resisting steels. No ferronickel was produced in the United States in 2009 from either domestic or imported ores, but International Metals Reclamation Company Inc., Ellwood City, PA, produced a remelt alloy from recycled materials, which typically averaged 13% chromium and 12% nickel. Stainless steel producers substituted the remelt alloy for ferrochromium and ferronickel. Almost all U.S. ferronickel exports were either re-exports or material upgraded for specialty purposes.

Ferrosilicon

Silicon ferroalloy consumption is driven by cast iron and steel production, where silicon alloys are used as deoxidizers. Some silicon metal was also used as an alloying agent with iron. On the basis of silicon content, U.S. net production of silicon ferroalloys (ferrosilicon and miscellaneous silicon alloys) was 126,000 t, 22% less than the revised amount of 161,000 t in 2008. On a gross weight basis, U.S. net production of ferrosilicon in 2009 (194,000 t) also decreased by 22% compared with that of 2008 (table 7). China produced more ferrosilicon than the rest of the world combined and more than five times that of the next two major producing countries—Norway and Russia—combined.

Ferrotitanium

Titanium is used in steelmaking for deoxidation, grain-size control, and carbon and nitrogen control and stabilization. During steelmaking, titanium is usually introduced as ferrotitanium because of its lower melting temperature and higher density compared with those of titanium scrap. Steels with relatively high titanium content include interstitial-free, stainless, and high-strength low-alloy steels. Ferrotitanium is usually produced by induction melting of titanium scrap with iron or steel; however, it also is produced directly from titanium mineral concentrates. The standard grades of ferrotitanium are 30% and 70% titanium. U.S. producers of ferrotitanium were Global Titanium Inc. (Detroit, MI), with 10,000 t/yr of ferrotitanium production capacity, and RTI International Metals, Inc. (Canton, OH), with 7,260 t/yr of ferrotitanium and specialty alloy production capacity. Ferrosilicon-titanium also is produced to allow the simultaneous addition of silicon and titanium. The leading ferrotitanium producing countries included China, India, Russia, Ukraine, United Kingdom, and the United States.

Global consumption of ferrotitanium was estimated to be about 50,000 t of contained titanium in 2009. In the United States, reported domestic consumption of titanium products in steel and other alloys was 9,290 t (gross weight), a 23%

decrease compared with that of 2008. Decreased global steel production in late 2008 and 2009 reduced the need for ferrotitanium worldwide; in response, ferrotitanium producers idled production capacity. In addition to curtailments that took place in 2008, F.E. Mottram Ltd. (United Kingdom) idled nearly all of its 5,000 t/yr of ferrotitanium production capacity (Metal-Pages, 2009). Even with production cutbacks, excess ferrotitanium inventories were on hand throughout the year.

Because of reduced consumption from steel producers, the average published price for 70%-grade ferrotitanium plummeted to $1.35 per pound (less than one-half of the yearend price in 2008). By yearend, however, the price increased to $2.16 per pound, a 28% decrease compared with that in 2008.

Ferrotungsten

Tungsten is an important alloying element in high-speed and other tool steels, and is used to a lesser extent in some stainless and structural steels. Tungsten can be added to steel melts as—(1) ferrotungsten, which is a master alloy containing between 75% and 80% tungsten; (2) tungsten melting base, which is a master alloy containing up to 36% tungsten; (3) tungsten metal scrap; or (4) scheelite ore concentrates (Lassner and Schubert, 199, p. 307–312; Roskill Information Services Ltd., 2007, p. 167–168, 174, 178–179).

World ferrotungsten production was dominated by China. In 2009, China produced an estimated 10,000 t, gross weight, of ferrotungsten. Chinese ferrotungsten exports decreased by 76% in 2009 to 1,160 t, gross weight, from 4,835 t, gross weight, in 2008. The decrease in ferrotungsten exports illustrated the effect of the global economic downturn on specialty steel production (Beijing Antaike Information Development Co., Ltd., 2010). U.S. reported consumption of ferrotungsten decreased slightly compared with that of 2008. Ferrotungsten prices decreased from those of 2008, with the Platts Metals Week price ranging between $25.50 and $30.00 per kilogram of contained tungsten during the year.

Ferrovanadium

In 2009, China, Russia, and South Africa accounted for 98% of world vanadium mine production. In these three countries, vanadium was primarily recovered from titanium-bearing magnetite ore processed to produce pig iron. The process produces a slag containing 20% to 24% vanadium pentoxide, which can be further processed to ferrovanadium containing 40% to 50% vanadium.

In 2009, vanadium recovery from various industrial waste materials, such as vanadium-bearing fly ash, petroleum residues, pig iron slag, and spent catalysts was the leading source of U.S. vanadium production. A small amount of vanadium was obtained as a coproduct from the mining of uraniferous sandstones on the Colorado Plateau.

The domestic steel industry accounted for the majority of U.S. reported vanadium consumption in 2009, principally in carbon, full alloy and high-strength, low-alloy steels. Of the 5,000 t of vanadium consumed in the United States, 78% came from ferrovanadium, a 3% decrease compared with the revised number of 2008. Steel manufacturing consumed almost all of the ferrovanadium in 2009 (table 4).

Outlook

The near-term trend for domestic ferroalloy consumption was expected to follow closely that of U.S. steel production. Details of the outlook for the steel industry are discussed in the Outlook section of the Iron and Steel chapter of the 2009 USGS Minerals Yearbook, volume I, Metals and Minerals. Crude steel production in the United States decreased by 35% to 59.3 Mt in 2009 from that in 2008 (American Iron and Steel Institute, 2010, p. 75). MEPS (International) Ltd. (2010) forecast world raw steel production would increase to 1.4 billion metric tons in 2010 from that in 2009, with a 21% increase in North American raw steel production to 100.5 Mt.

Changes in steel production reflect changes in apparent use of steel. The World Steel Association (2010) reported that U.S. apparent steel use in 2009 decreased by 36% to 59.2 Mt, owing to U.S. economic problems. However, domestic apparent steel use was expected to increase by 33% in 2010 and then by 9% to 86.1 Mt in 2011, as a result of the recovery in U.S. manufacturing and the rebuilding of steel stocks.

Chromium, manganese, silicon, and other ferroalloy metals are discussed in more detail, including domestic data coverage, outlook, and U.S. Government stockpile information, in the respective mineral commodity chapters in the U.S. Geological Survey Minerals Yearbook, volume I, Metals and Minerals.

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TABLE 1
DOMESTIC PRODUCERS OF FERROALLOYS IN 2009

		Products[1]							
Company	Plant location	FeCr	FeMo	FeMn	FeNb	FeSi	FeTi	FeV	SiMn
Bear Metallurgical Co.	Butler, PA		X					X	
CC Metals & Alloys, LLC	Calvert City, KY					X			
Core Metals Group[2]	Bridgeport, AL					X			
Eramet Marietta Inc.	Marietta, OH	X		X					X
Felman Production Inc.	Letart, WV								X
Global Titanium Inc.	Detroit, MI						X		
Globe Metallurgical Inc.[2]	Beverly, OH					X			
Metallurg Vanadium Corp.	Cambridge, OH							X	
Reading Alloys Inc.	Robesonia, PA				X				
RTI International Metals, Inc.	Canton, OH						X		
Stratcor, Inc.	Hot Springs, AR							X	
Thompson Creek Metals Co. Inc.	Langeloth, PA		X						

[1] FeCr, ferrochromium; FeMo, ferromolybdenum; FeMn, ferromanganese; FeNb, ferroniobium; FeSi, ferrosilicon; FeTi, ferrotitanium; FeV, ferrovanadium; SiMn, silicomanganese.

[2] Owned by Globe Specialty Metals.

TABLE 2
GOVERNMENT INVENTORY OF FERROALLOYS, DECEMBER 31, 2009[1, 2]

(Metric tons of alloys unless otherwise specified)

Alloy	Inventory
Ferrochromium:	
High-carbon	113,000
Low-carbon	61,500
Ferromanganese, high carbon	403,000

[1] Data are rounded to no more than three significant digits.

[2] Data are uncommitted inventory.

Source: Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center).

TABLE 3

REPORTED U.S. CONSUMPTION OF FERROALLOYS AS ALLOYING ELEMENTS BY END USE IN 2009[1,2]

(Metric tons of alloys unless otherwise specified)

		Manganese				
End use	FeB	FeMn	SiMn	FeP	FeSi	FeTi
Steel:						
Carbon and high-strength low-alloy	470	196,000	62,000	2,920	28,400 [3,4,5]	4,830
Stainless and heat-resisting	(3)	9,710	14,200	(3)	41,100 [3]	2,600
Other alloy	(3)	28,700	13,500	(3)	11,300 [3,5]	348
Tool	(3)	(3)	(3)	--	(3)	(6)
Unspecified	272	3,180	922	678	56,900 [5]	--
Total steel	742	238,000	90,600	3,600	138,000	7,780
Cast irons	(5)	6,910 [7]	406	(5)	88,200 [5]	12
Superalloys	37	350 [7]	--	4	(4), (5)	462
Alloys (excluding alloy steels and superalloys)	(5)	11,300	2,750	(5)	50,800 [4,5]	993
Miscellaneous and unspecified	334	(7)	(7)	816	179,000 [4]	42
Grand total	1,110	257,000	93,700 [8]	4,420	456,000	9,290
Total 2008	1,140	327,000 [r]	113,000 [8]	5,210	532,000 [r]	12,000 [r]
Percentage of 2008	98	79	83	85	86	77
Consumer stocks, December 31	183	32,000 [9]	25,800 [9]	823	13,600	1,250

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] FeB, ferroboron, including other boron materials; FeMn, ferromanganese, including manganese metal; SiMn, silicomanganese; FeP, ferrophosphorus, including other phosphorus materials; FeSi, ferrosilicon, including silicon metal, silvery pig iron, silicon carbide, and inoculant alloys; FeTi, ferrotitanium, including titanium scrap and other titanium materials.

[3] All or part included with "Steel, unspecified."

[4] All or part included with "Cast irons."

[5] All or part included with "Miscellaneous and unspecified."

[6] All or part included with "Steel, other alloy."

[7] All or part included with "Alloys (excluding alloy steels and superalloys)."

[8] Internal evaluation indicates that silicomanganese consumption is considerably understated.

[9] Consumer and producer stocks.

TABLE 4

REPORTED U.S. CONSUMPTION OF FERROALLOYS AS ALLOYING ELEMENTS BY END USE IN 2009[1,2]

(Metric tons of contained elements unless otherwise specified)

End use	FeCr	FeMo	FeNb	FeNi	FeV	FeW
Steel:						
Carbon and high-strength low-alloy	4,180	414	1,620	--	W	(3)
Stainless and heat-resisting	188,000	768	551	8,470	119	(3)
Other alloy	8,200	2,500	(4)	400	1,710	(3)
Tool	(4)	W	(4)	--	64	(3)
Unspecified	16,000	--	1,030	--	--	--
Total	217,000	3,680	3,200	8,870	1,900	246
Cast irons	(5)	314	--	--	W	--
Superalloys	6,920	15	1,130	W	11	(3)
Alloys (excluding alloy steels and superalloys)	9,400 [6]	75	21	W	W	(3)
Miscellaneous and unspecified	(5)	86	--	260	2,000	--
Grand total	233,000	4,170	4,350	9,130	3,910	246
Total 2008	255,000 [r]	5,560	5,380 [r]	11,200 [r]	4,190	253
Percentage of 2008	91	75	81	81	93	97
Consumer stocks, December 31	6,990	325	321	733	232	16

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] FeCr, ferrochromium, including other chromium ferroalloys and chromium metal; FeMo, ferromolybdenum, including calcium molybdate; FeNb, ferroniobium, including nickel niobium; FeNi, ferronickel; FeV, ferrovanadium, including other vanadium-carbon-iron ferroalloys; and FeW, ferrotungsten.

[3] Included with "Steel, total."

[4] Included with "Steel, unspecified."

[5] Included with "Alloys (excluding alloy steels and superalloys)."

[6] Includes "Cast irons," "Alloys (excluding alloy steel and superalloys)," and "Miscellaneous and unspecified" uses.

TABLE 5
FERROALLOY PRICES IN 2009

	High	Low	Average
Chromium:			
Ferrochromium:			
0.05% carbon[1]	280.00	210.00	234.79
0.10% carbon[1]	255.00	190.00	207.28
0.15% carbon[1]	210.00	175.00	190.80
Over 4% carbon:			
49–51% chromium[1]	92.00	66.00	80.12
60–65% chromium[1]	92.00	65.75	80.95
Manganese:			
Medium-carbon ferromanganese[1]	140.00	80.00	100.52
Standard high-carbon ferromanganese[2]	1,475.00	880.00	1,208.16
Silicomanganese[3]	73.00	34.00	50.72
Molybdenum:			
Ferromolybdenum[4]	12.69	12.22	12.46
Molybdenum oxide[4]	11.41	11.05	11.23
Silicon:			
50% ferrosilicon[1]	90.00	60.00	76.93
75% ferrosilicon[1]	81.00	52.00	68.91
Silicon metal[1]	140.00	102.00	116.37
Vanadium, ferrovanadium[4]	11.19	10.71	10.95

[1] Cents per pound of contained element.

[2] Dollars per gross ton.

[3] Cents per pound.

[4] Dollars per pound of contained element.

Sources: Platts Metals Week and Ryan's Notes.

TABLE 6

U.S. IMPORTS FOR CONSUMPTION AND EXPORTS OF FERROALLOYS AND FERROALLOY METALS IN 2009[1]

	Imports			Exports		
Alloy	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)
Ferroalloys:						
Chromium ferroalloys:						
Ferrochromium containing:						
More than 4% carbon	198,000	109,000	$167,000	3,200	1,770	$4,270
Not more than 4% carbon	XX	XX	XX	1,560	710	2,440
More than 3% but not more than 4% carbon	3,180	1,720	1,720	XX	XX	XX
More than 0.5% but not more than 3% carbon	2,110	1,280	4,290	XX	XX	XX
Not more than 0.5% carbon	36,600	24,800	111,000	XX	XX	XX
Ferrochromium-silicon	7,560	3,120	9,140	19	6	109
Total	248,000	140,000	294,000	4,780	2,490	6,820
Manganese ferroalloys:						
Ferromanganese containing:						
More than 4% carbon	106,000	81,600	119,000	XX	XX	XX
More than 2% but not more than 4% carbon	637	496	986	XX	XX	XX
More than 1% but not more than 2% carbon	26,600	21,400	52,600	XX	XX	XX
Not more than 1% carbon	20,100	17,200	42,700	XX	XX	XX
Ferromanganese, all grades	XX	XX	XX	24,200	XX	27,900
Silicomanganese	130,000	83,500	135,000	18,800	XX	17,500
Total	284,000	204,000	351,000	42,900	XX	45,400
Silicon ferroalloys:						
Ferrosilicon containing:						
More than 55% silicon	XX	XX	XX	10,600	6,950	10,700
More than 55% but not more than 80% silicon and more than 3% calcium	1,650	1,070	2,760	XX	XX	XX
Magnesium ferrosilicon	11,100	5,150	20,500	XX	XX	XX
Ferrosilicon, other[2, 3]	90,100	63,300	103,000	3,650	1,720	6,200
Total	103,000	69,600	126,000	14,200	8,670	16,900
Other ferroalloys:						
Ferrocerium and other pyrophoric alloys and other	1,100	XX	5,370	XX	XX	XX
Ferromolybdenum	3,040	2,030	50,100	1,200	827	22,400
Ferronickel	19,500	6,200	84,900	54	32	1,050
Ferroniobium	4,490	XX	109,000	240	XX	2,740
Ferrophosphorus	138	XX	617	1,130	XX	2,080
Ferrotitanium and ferrosilicon-titanium	2,540	XX	6,750	2,020	XX	7,360
Ferrotungsten and ferrosilicon-tungsten	60	46	1,260	2	1	55
Ferrovanadium	476	353	12,600	971	672	15,000
Ferrozirconium	(4)	XX	7	566	XX	1,140
Ferroalloys, other	4,710	XX	13,900	3,130	XX	6,840
Total	36,000	8,620	284,000	9,310	1,530	58,600
Total ferroalloys	670,000	422,000	1,060,000	71,200	12,700	128,000
Metals:						
Chromium (total, all grades)	7,570	XX	74,900	411	XX	13,300
Manganese:						
Metal, including alloys and waste and scrap	XX	XX	XX	3,150	XX	8,090
Unwrought	21,500	XX	55,000	XX	XX	XX
Other manganese, wrought	614	XX	2,450	XX	XX	XX
Silicon:						
Less than 99% silicon	10,800	10,100	25,000	4,200	4,070	8,030
Less than 99.99% but not less 99% silicon	102,000	100,000	256,000	1,840	1,830	4,340
Not less than 99.99% silicon	2,850	XX	196,000	31,800	XX	2,060,000
Total metals	145,000	110,000	609,000	41,400	5,900	2,090,000
Grand total	815,000	532,000	1,660,000	113,000	18,600	2,220,000

XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 6—Continued

U.S. IMPORTS FOR CONSUMPTION AND EXPORTS OF FERROALLOYS AND FERROALLOY METALS IN 2009[1]

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[2] Includes less than 55% silicon and 55% to 80% silicon, other.

[3] Includes imports of ferrosilicon containing 80% to 90% silicon and more than 90% silicon.

[4] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons, gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2005	2006	2007	2008	2009[e]
Albania, electric furnace, ferrochromium	34,400	17,040	--	11,916	7,556 [6]
Argentina, electric furnace:					
Ferrosilicon[e]	25,700 [r]	24,400 [r]	15,000 [r]	10,400 [r]	11,300
Silicomanganese	13,290 [r]	9,268 [r]	8,917 [r]	9,172 [r]	6,644 [6]
Total[e]	39,000 [r]	33,700 [r]	23,900 [r]	19,600 [r]	17,900
Armenia, electric furnace, ferromolybdenum	2,260	4,865	5,977	5,325 [r]	5,144 [6]
Australia, electric furnace:[e]					
Ferromanganese	120,000	125,000	115,000 [r]	147,000 [r]	87,000
Silicomanganese	120,000 [r]	120,000 [r]	110,000 [r]	125,000 [r]	74,000
Silicon metal	35,000	35,000	35,000	35,000	30,000
Total	275,000 [r]	280,000 [r]	260,000 [r]	307,000 [r]	191,000
Austria, electric furnace:[e]					
Ferronickel, including ferronickel molybdenum	3,100	2,800	2,800	1,550 [r]	2,150
Other	4,000	3,600 [r]	3,600 [r]	3,600 [r]	2,000
Total	7,100	6,400 [r]	6,400 [r]	5,150 [r]	4,150
Bhutan, electric furnace, ferrosilicon[e]	20,000	20,000	21,000	36,600	36,600
Bosnia and Herzegovina, electric furnace, net exports:[e]					
Ferrosilicon	14,600 [r]	1,300 [r]	860 [r]	640 [r]	470
Silicon metal	5,290 [r]	15,200 [r]	11,600 [r]	12,400 [r]	11,000
Total	19,900 [r]	16,500 [r]	12,500 [r]	13,000 [r]	11,500
Brazil, electric furnace:					
Ferrochromium[7]	197,653	166,577	195,890	194,323 [r]	194,500 [p, 6]
Ferrochromium silicon	11,600	11,600 [e]	11,600 [e]	11,507 [r]	11,510 [p, 6]
Ferromanganese	182,400	280,770	205,000 [r, e]	190,000 [r, e]	66,000
Ferronickel	28,500 [r, e]	29,100 [r, e]	27,636 [r]	29,223 [r]	26,700 [p]
Ferroniobium (ferrocolumbium)	38,819 [r]	41,566 [r]	52,442 [r]	38,490 [r]	38,500 [p]
Ferrosilicon	146,000 [r]	146,000 [r, e]	146,000 [r, e]	144,832 [r]	145,000 [p]
Ferrotitanium	NA	NA	NA	NA	NA
Silicomanganese	297,600	292,230	214,000 [r, e]	198,000 [r, e]	69,000
Silicon metal	133,400 [r]	133,000 [r, e]	133,000 [r, e]	131,940 [r]	132,000 [p]
Other	19,500 [r]	19,500 [r, e]	19,500 [r, e]	19,344 [r]	19,350 [p, 6]
Total	1,055,472 [r]	1,120,343 [r]	1,005,068 [r, e]	957,659 [r]	703,000 [p]
Bulgaria, electric furnace, ferrosilicon[e]	10,000	10,000	10,000	6,260 [r]	2,600
Canada, electric furnace:[e]					
Ferroniobium (ferrocolumbium)	5,621 [6]	6,298 [6]	6,571 [6]	6,644 [6]	6,000
Ferrosilicon	35,000	35,000	35,000	35,000	37,000
Ferrovanadium	1,000	1,000	1,000	1,000	900
Silicon metal	30,000	30,000	30,000	50,000	30,000
Total	71,600	72,300	72,600	92,600	73,900
Chile, electric furnace, ferromolybdenum	9,248	14,001	14,828	16,918	10,820 [6]
China:[e]					
Blast furnace:					
Ferromanganese	500,000	600,000	600,000	600,000	500,000
Other	60,000	60,000	50,000	50,000	30,000
Total, blast furnace	560,000	660,000	650,000	650,000	530,000
Electric furnace:					
Ferrochromium	850,000	1,000,000	1,300,000	1,500,000 [r]	1,550,000
Ferromanganese	1,150,000	1,400,000	1,930,000	2,100,000	2,300,000
Ferromolybdenum	80,000	90,000	60,000	80,000 [r]	90,000

See footnotes at end of table.

TABLE 7—Continued
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons, gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2005	2006	2007	2008	2009[e]
China—Continued:[e]					
Electric furnace—Continued:					
Ferronickel and high nickel pig iron[8]	48,000	390,000	845,000	590,000	600,000
Ferrosilicon	3,300,000	4,020,000	4,710,000	4,900,000	5,200,000
Ferrotitanium	NA	NA	NA	NA	NA
Silicomanganese	3,000,000	3,600,000	4,340,000	5,000,000 [r]	5,200,000
Silicon metal	840,000	900,000	950,000	980,000	950,000
Other	920,000 [r]	2,630,000 [r]	3,560,000 [r]	3,230,000 [r]	3,050,000
Total, electric furnace	10,200,000	14,000,000	17,700,000	18,400,000	19,000,000
Total, blast and electric furnaces	10,700,000	14,700,000	18,300,000	19,000,000 [r]	19,500,000
Colombia, electric furnace, ferronickel	122,700 [r]	118,900 [r]	114,600 [r]	112,784 [r]	160,477 [6]
Czech Republic, electric furnace, other[e]	2,700	2,800	2,800	2,800	--
Dominican Republic, electric furnace, ferronickel	73,962	76,659	75,067 [r]	47,408 [r]	-- [6]
Egypt, electric furnace:[e]					
Ferromanganese	30,000	30,000	30,000	30,000	30,000
Ferrosilicon	55,000	50,000	50,000	50,000	50,000
Total	85,000	80,000	80,000	80,000	80,000
Finland, electric furnace, ferrochromium	234,881	243,350	241,760	233,550	123,310 [6]
France, electric furnace:[e]					
Ferromanganese	113,000 [r]	137,000 [r]	144,000 [r]	46,600 [r]	46,000
Ferrosilicon	67,000	67,000	71,000	25,000 [r]	25,000
Silicomanganese	52,300	63,300	65,400 [r]	60,200 [r]	54,100
Silicon metal	75,000 [r]	85,000 [r]	85,000 [r]	85,000 [r]	51,000
Other	65,000	60,000	60,000	60,000	60,000
Total	372,000 [r]	412,000 [r]	425,000 [r]	277,000 [r]	236,000
Georgia, electric furnace:					
Ferromanganese	13,945	5,130	5,000 [e]	5,000 [e]	4,500
Silicomanganese	109,414	116,945	120,000 [e]	120,000 [e]	105,000
Total	123,359	122,075	125,000 [e]	125,000 [e]	110,000
Germany, electric furnace:					
Ferrochromium	22,672	26,710	22,030	26,960	13,667 [6]
Silicon metal	29,349	35,500	35,245	35,000 [r, e]	20,000
Other[e, 9]	25,400	24,100	5,000	5,000	--
Total	77,421	86,310	62,275	66,960 [r]	33,667 [6]
Greece, electric furnace, ferronickel[e]	95,000	88,000	90,000	87,664 [r, 6]	42,423 [6]
Hungary, electric furnace:[e, 10]					
Ferrosilicon	-- [r]	-- [r]	-- [r]	-- [r]	--
Silicon metal	-- [r]	-- [r]	-- [r]	-- [r]	--
Total	-- [r]	-- [r]	-- [r]	-- [r]	--
Iceland, electric furnace, ferrosilicon[e]	120,000	113,798 [6]	110,000 [r]	100,000 [r]	125,000
India, electric furnace:[11]					
Ferroaluminum	7,214	9,947	9,377	8,170	7,017 [6]
Ferroboron	75	80	80	83	90 [6]
Ferrochromium[12]	662,297 [r]	801,368 [r]	948,601 [r]	817,239 [r]	892,100 [6]
Ferrochromium silicon[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
Ferromanganese	273,057 [r]	296,726 [r]	391,210 [r]	384,577 [r]	389,465 [6]
Ferromolybdenum	2,827	3,120	2,899	2,162	2,822 [6]
Ferronickel magnesium	--	97	122	221	209 [6]
Ferroniobium (ferrocolumbium)	-- [r]	-- [r]	-- [r]	-- [r]	--

See footnotes at end of table.

TABLE 7—Continued

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons, gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2005	2006	2007	2008	2009[e]
India, electric furnace—Continued:					
Ferrosilicomagnesium	11,171	11,387	13,525	13,400	17,132 [6]
Ferrosilicon	93,000 [r]	92,000 [r]	86,000 [r]	93,000 [r]	91,000
Ferrosilicozirconium	87	178	109	87	120 [6]
Ferrotitanium	735	1,761	1,937	1,661	2,379 [6]
Ferrotungsten	63	54	51	150	150 [6]
Ferrovanadium	877	1,139	1,585	1,501	1,769 [6]
Silicomanganese	596,372 [r]	782,962 [r]	911,402 [r]	891,458 [r]	1,099,838 [6]
Other	-- [r]	-- [r]	-- [r]	-- [r]	--
Total	1,647,775 [r]	2,000,819 [r]	2,366,898 [r]	2,213,709 [r]	2,504,091 [6]
Indonesia, electric furnace:					
Ferromanganese[e]	12,000	12,000	12,000	12,000	12,000
Ferronickel	36,690	72,300	92,500	87,800 [r]	62,750 [6]
Silicomanganese[e]	4,000	5,000	6,000	7,000	7,000
Total	52,690	89,300	110,500	106,800 [r]	81,800
Iran, electric furnace:[e]					
Ferrochromium	8,000	7,000	8,000	8,000	8,000
Ferromanganese	NA	NA	NA	NA	NA
Ferrosilicon	50,000	45,000	45,000	45,000	45,000
Total	58,000	52,000	53,000	53,000	53,000
Italy, electric furnace:[e]					
Ferromanganese	9,000 [r]	4,500 [r]	4,800 [r]	8,500 [r]	5,500
Silicomanganese	21,500 [r]	33,500 [r]	37,000 [r]	25,500 [r]	17,000
Other[13]	10,000	10,000	10,000	10,000	10,000
Total	40,500 [r]	48,000 [r]	51,800 [r]	44,000 [r]	32,500
Japan, electric furnace:					
Ferrochromium[14]	12,367	13,056	12,016	13,888 [r]	7,698 [6]
Ferromanganese	448,616	406,162	420,151	431,181 [r]	361,375 [6]
Ferronickel	391,074	335,884	351,503	301,361 [r]	284,884 [6]
Ferrovanadium	--	--	--	3,477	2,560 [6]
Ferrotitanium	NA	NA	NA	NA	NA
Silicomanganese	94,725	59,424	52,901	58,884 [r]	49,205 [6]
Other[15]	16,436	19,394	21,760	14,478 [r]	12,957 [6]
Total	963,218	833,920	858,331	823,269 [r]	718,679 [6]
Kazakhstan, electric furnace:					
Ferrochromium	1,156,168	1,200,000 [e]	1,307,536	1,220,315	1,100,000
Ferrochromium silicon	97,870	100,000 [e]	145,695	133,828	125,000
Ferromanganese[e]	2,100	2,100	2,100	2,100	1,900
Ferrosilicon	104,185	105,000 [e]	59,886	54,964	55,400
Silicomanganese	170,214	220,000 [e]	188,445	179,939	160,000
Other[e]	9,000	9,000	9,000	9,000	8,500
Total	1,539,537	1,640,000 [e]	1,712,662	1,600,146	1,450,000
Korea, North, electric furnace, other[e]	10,000	10,000	10,000	10,000	10,000
Korea, Republic of, electric furnace:					
Ferromanganese	124,434	169,202	209,321	251,125	250,000
Ferronickel	--	--	--	6,600	56,900
Silicomanganese	74,193	94,119	105,607	76,184	80,000
Other	3,670	3,653	4,224	4,000 [e]	4,000
Total	202,297	266,974	319,152	337,909	391,000

See footnotes at end of table.

TABLE 7—Continued
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons, gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2005	2006	2007	2008	2009[e]
Kosovo, ferronickel	--	--	2,100 [r, 1]	18,500 [r, 1]	12,400
Macedonia, electric furnace:					
Ferromanganese	--	--	--	12,623	--
Ferronickel	36,800	49,500	68,200	66,900 [r, e]	53,100
Ferrosilicon	71,249	59,023	34,215	42,674	7,657 [6]
Silicomanganese	--	--	70,472	54,931	--
Total	108,049	108,523	172,887	177,128 [r]	60,757 [6]
Mexico, electric furnace:[17]					
Ferromanganese	89,642	62,485	74,578	97,366	42,492 [6]
Silicomanganese	104,780	97,457	109,286	114,320	85,065 [6]
Total	194,422	159,942	183,864	211,686	127,557 [6]
New Caledonia, electric furnace, ferronickel	155,800	162,400	151,100	144,300	147,200 [6]
Norway, electric furnace:[e]					
Ferromanganese	250,000	245,000	245,000	309,000 [r]	205,000
Ferrosilicon	165,000	93,000	217,000 [r]	250,575 [r, 6]	207,337 [6]
Silicomanganese	230,000	230,000	225,000	252,000 [r]	200,000
Silicon metal	105,000	100,000	145,782 [r, 6]	180,135 [r, 6]	169,643 [6]
Other[9]	15,000	15,000	15,000	15,000	15,000
Total	765,000	683,000	848,000 [r]	1,010,000 [r]	797,000
Peru, electric furnace, ferrosilicon[e]	600	600	600	600	600
Poland:					
Blast furnace, ferromanganese	7,800	4,100	2,100 [r]	4,100 [r, e]	4,100
Electric furnace:					
Ferrosilicon	65,118 [r]	13,034 [r]	58,538	56,031	56,000
Silicomanganese	10,242	3,310	15,600 [r]	24,000 [r, e]	24,000
Total, electric furnace	75,360	16,344	74,138	80,031	80,000
Total, blast and electric furnaces	83,160 [r]	20,444 [r]	76,238 [r]	84,131 [r]	84,100
Romania, electric furnace:					
Ferromanganese	18,625	3,329	--	--	--
Silicomanganese	100,957	53,085	26,868	10,000	--
Total	119,582	56,414	26,868	10,000	--
Russia:[e]					
Blast furnace:					
Ferromanganese	110,000	130,000	120,000	110,000	100,000
Ferrophosphorus	3,500	3,500	3,500	3,500	3,000
Spiegeleisen	7,000	7,000	7,000	7,000	6,500
Total, blast furnace	121,000	141,000	131,000	121,000	110,000
Electric furnace:					
Ferrochromium	578,000 [6]	600,000	570,000	490,000 [r, e]	378,000 [6]
Ferrochromium silicon	4,000	4,000	4,000	4,000	3,500
Ferronickel:					
High-nickel[18]	14,800 [6]	16,085 [6]	19,031 [6]	17,971 [6]	17,489 [6]
Other[19]	11,800 [r]	12,300 [r]	12,800 [r]	13,400 [r]	14,000
Ferroniobium (ferrocolumbium)	--	--	121	121	120
Ferrosilicon	742,000 [6]	882,300 [6]	896,100 [6]	850,000	745,000
Ferrotitanium	NA	NA	NA	NA	NA
Ferrovanadium	12,880 [6]	11,000	12,000	12,000	11,500

See footnotes at end of table.

TABLE 7—Continued

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1,2]

(Metric tons, gross weight)

Country, furnace type, and alloy type[3,4,5]	2005	2006	2007	2008	2009[e]
Russia—Continued:[e]					
Electric furnace—Continued:					
Silicomanganese	48,000	40,000	40,000	40,000	35,000
Silicon metal	58,000	54,500	54,000	54,000	54,000
Other	22,000	22,000	22,000	22,000	20,000
Total, electric furnace	1,490,000	1,640,000	1,630,000	1,500,000	1,280,000
Total, blast and electric furnaces	1,610,000	1,780,000	1,760,000	1,620,000 [r]	1,390,000
Saudi Arabia, electric furnace, other[e]	--	85,000	85,000	90,000	90,000
Slovakia, electric furnace:					
Ferrochromium	867	19	--	--	--
Ferromanganese	43,458	59,391	74,065	61,194	60,000
Ferrosilicon	16,512	16,155	8,583	10,844 [r]	8,622 [6]
Silicomanganese	47,843	59,128	71,587	59,940	60,000
Other[e]	5,000	5,000	5,000	--	--
Total	113,680	139,693	159,235	131,978 [r]	129,000
Slovenia, electric furnace, ferrosilicon	15,529	12,550	6,000 [e]	--	--
South Africa, electric furnace:					
Ferrochromium	2,812,000	3,030,000	3,552,000 [r]	3,269,000 [r]	2,800,000
Ferromanganese	570,574	656,235	698,654	503,000 [r]	260,000
Ferronickel, high-nickel	120	133	6,667	5,733	1,067 [6]
Ferrosilicon	127,000	148,900	140,000 [r]	135,000 [r]	120,000
Ferrovanadium[e]	19,000	18,000	19,000	19,000 [r]	17,000
Silicomanganese[e]	231,000	247,000	302,000	233,000 [r]	110,000
Silicon metal	53,500	53,300	50,300	51,800 [r]	39,000
Other[e, 21]	-- [r]	-- [r]	-- [r]	-- [r]	--
Total	3,813,194 [r]	4,153,568 [r]	4,768,621 [r]	4,216,533 [r]	3,350,000
Spain, electric furnace:[e]					
Ferromanganese	10,000	10,000	10,000	10,000	10,000
Ferrosilicon	70,000	67,000	71,000	22,000	22,000
Silicomanganese	100,000	100,000	100,000	30,000 [r]	30,000
Silicon metal	32,000	32,000	32,000	12,000 [r]	8,000
Other	5,000	5,000	5,000	5,000	5,000
Total	217,000	214,000	218,000	79,000 [r]	75,000
Sweden, electric furnace:					
Ferrochromium	127,451	136,374	124,403	117,053	31,345 [6]
Ferrosilicon[e]	9,800	4,000	5,000	5,000	5,000
Total	137,251	140,374	129,403	122,053	36,345 [6]
Turkey, electric furnace:					
Ferrochromium	26,043	67,975	69,730	75,840 [r]	41,028 [6]
Ferrosilicon[e]	--	5,000	5,000	5,000	4,000
Total	26,043	72,975	74,730	80,840 [r]	45,028 [6]
Ukraine:					
Blast furnace:[e]					
Ferromanganese	79,000 [r, 6]	30,000 [r, 6]	26,700 [r, 6]	16,000 [r, 6]	--
Spiegeleisen	5,000	5,000	4,450 [r]	4,730 [r]	4,700
Total, blast furnace	84,000	35,000	31,200	20,700	4,700
Electric furnace:					
Ferromanganese	359,000	373,000	368,000	361,501 [r]	129,400 [6]
Ferronickel	61,166 [r]	79,338 [r]	79,530 [r]	89,825 [r]	61,449 [6]

See footnotes at end of table.

TABLE 7—Continued
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons, gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2005	2006	2007	2008	2009[e]
Ukraine—Continued:					
Electric furnace—Continued:					
Ferrosilicon	228,000	169,000 [r]	218,000 [r]	152,800 [r]	150,300 [6]
Ferrotitanium	NA	NA	NA	NA	NA
Silicomanganese	1,040,000	1,168,000	1,281,000	958,667 [r]	741,900 [6]
Other[e]	25,000	25,000	25,000	43,127 [r, 6]	23,882 [6]
Total, electric furnace	1,713,166	1,814,338	1,971,530	1,605,920	1,106,931 [6]
Total, blast and electric furnaces	1,797,166 [r]	1,849,338 [r]	2,002,680 [r]	1,626,650 [r]	1,111,631 [6]
United Kingdom, electric furnace, ferrotitanium	NA	NA	NA	NA	NA
United States, electric furnace:					
Ferrochromium[20]	W	W	W	W	W
Ferromanganese[21]	W	W	W	W	W
Ferroniobium (ferrocolumbium)	NA	NA	NA	NA	NA
Ferrosilicon[22]	164,000	194,000	220,000	248,000 [r]	194,000 [6]
Ferrotitanium	NA	NA	NA	NA	NA
Silicon metal[22]	143,000	W	W	W	W
Other[23]	W	W	W	W	W
Total	307,000	194,000	220,000	248,000 [r]	194,000 [6]
Uruguay, electric furnace, ferrosilicon[e]	200	200	200	200	200
Venezuela, electric furnace:[e]					
Ferromanganese	15,000	15,000	15,000	15,000	15,000
Ferronickel	73,063 [r, 6]	75,313 [r, 6]	68,506 [r, 6]	42,300 [r, 6]	40,113 [6]
Ferrosilicon	92,000 [r, 6]	92,000 [r]	92,000 [r]	92,000 [r]	83,000
Silicomanganese	35,000	35,000	35,000	35,000	35,000
Total	215,000 [r]	217,000 [r]	211,000 [r]	184,000 [r]	173,000
Zimbabwe, electric furnace:					
Ferrochromium	238,507 [r]	200,673 [r]	187,327 [r]	145,430 [r]	72,223 [6]
Ferrochromium silicon	4,882 [r]	1,024 [r]	3,097 [r]	1,612 [r]	603 [6]
Total	243,389 [r]	201,697 [r]	190,424 [r]	147,042 [r]	72,826 [6]
Grand total:	28,000,000 [r]	32,800,000 [r]	37,900,000 [r]	37,000,000 [r]	34,600,000
Of which:					
Blast furnace:					
Ferromanganese	697,000 [r]	764,000 [r]	749,000 [r]	730,000 [r]	604,000
Spiegeleisen	12,000	12,000	11,500 [r]	11,700 [r]	11,200
Other[24]	63,500	63,500	53,500	53,500	33,000
Total, blast furnace	772,000 [r]	840,000 [r]	814,000 [r]	795,000 [r]	648,000
Electric furnace:					
Ferrochromium[25]	6,960,000 [r]	7,510,000 [r]	8,540,000 [r]	8,120,000 [r]	7,220,000
Ferrochromium silicon	118,000 [r]	117,000 [r]	164,000 [r]	151,000 [r]	141,000
Ferromanganese	3,830,000 [r]	4,290,000 [r]	4,950,000 [r]	4,980,000 [r]	4,280,000
Ferromolybdenum	85,100	98,000	68,900	87,500	98,000
Ferronickel[19]	1,150,000 [r]	1,510,000 [r]	2,010,000	1,660,000 [r]	1,580,000
Ferroniobium (ferrocolumbium)[26]	44,400 [r]	47,900 [r]	59,100 [r]	45,300 [r]	44,600
Ferrosilicon	5,810,000 [r]	6,490,000 [r]	7,330,000 [r]	7,370,000 [r]	7,430,000
Ferrovanadium[e]	33,800	31,100	33,600	37,000	33,700
Silicomanganese	6,500,000 [r]	7,430,000 [r]	8,440,000 [r]	8,560,000 [r]	8,240,000
Silicon metal	1,540,000 [r]	1,470,000 [r]	1,560,000 [r]	1,630,000 [r]	1,490,000
Other[27]	1,180,000 [r]	2,970,000 [r]	3,890,000 [r]	3,570,000 [r]	3,360,000
Total, electric furnace	27,300,000 [r]	32,000,000 [r]	37,000,000 [r]	36,200,000 [r]	33,900,000

See footnotes at end of table.

TABLE 7—Continued

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

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[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." NA Not available. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 20, 2010.

[3] In addition to the countries listed, ferrotungsten is produced in China, Russia, and Vietnam; Austria and Germany are thought to have produced ferroniobium (ferrocolumbium); and Iran is thought to have produced ferromanganese, ferromolybdenum, and silicomanganese, but production information is inadequate for the formulation of estimates of output levels.

[4] To the extent possible, ferroalloy production of each country has been separated according to the furnace from which production is obtained; production derived from metallothermic operation is included with electric furnace production.

[5] To the extent possible, ferroalloy production of each country has been separated to show the following individual major types of ferroalloys: ferrochromium, ferrochromium silicon, ferromanganese, ferromolybdenum, ferronickel, ferroniobium (ferrocolumbium), ferrosilicon, ferrovanadium, silicomanganese, silicon metal, and spiegeleisen. Ferroalloys other than those listed that have been identified specifically in sources, as well as those ferroalloys not identified specifically, but which definitely exclude those listed previously in this footnote, have been reported as "Other." Where one or more of the individual ferroalloys listed separately in this footnote have been inseparable from other ferroalloys owing to a nation's reporting system, deviations are indicated by individual footnotes.

[6] Reported figure.

[7] Includes high- and low-carbon ferrochromium.

[8] China currently makes several different types of ferronickel. These products range from a low nickel pig iron (for example, Zhejiang Huaguang Smelting Group Co., Ltd., 8.5% to 9.0% nickel) to high nickel ferronickel carbonyl powder (Jilin Jien Nickel Industry Co., Ltd., 70% to 80% nickel). The gross weight figures are based on average estimated content ranging from 20% to 25% nickel.

[9] Includes, if any, ferrochromium silicon, ferronickel, and silicomanganese.

[10] Hungary is thought to produce some blast furnace ferromanganese.

[11] Reported on a fiscal year basis, which is from April 1 to March 31.

[12] Includes charge chrome and ferrochrome.

[13] Excludes calcium-silicon.

[14] Includes high- and low-carbon ferrochromium and ferrochromium silicon.

[15] Includes calcium-silicon, ferrocolumbium, ferromolybdenum, ferrovanadium, and other ferroalloys.

[16] On February 17, 2008, the Kosovo Assembly declared independence from Serbia. Serbia's ferronickel data for 2004–07 are not available.

[17] Salable products from Cía Minera Autlán S.A. de C.V.

[18] Low-iron ferronickel containing greater than 85% nickel.

[19] Includes ferronickel chromium and Ni-resist cast iron produced from scrap.

[20] U.S. output of ferrochromium includes chromium metal, high- and low-carbon ferrochromium, ferrochromium silicon, and other chromium materials.

[21] U.S. output of ferromanganese includes manganese metal and silicomanganese.

[22] Net production.

[23] May include ferroboron, ferrocolumbium, ferromolybdenum, ferrophosphorus, ferrotitanium, ferrovanadium, nickel columbium, and silvery pig iron.

[24] Includes ferrophosphorus and data contained in "Blast furnace: Other."

[25] Ferrochromium includes ferrochromiumsilicon, if any, for Japan, South Africa, and the United States.

[26] In addition to the countries listed, Austria, China, and Germany are thought to have produced ferroniobium (ferrocolumbium), but production information is inadequate to make reliable estimates of output levels.

[27] Includes ferroaluminum, ferroboron, ferronickel magnesium, ferrosilicon magnesium, ferrosilicozirconium, ferrotitanium, and ferrotungsten.

FLUORSPAR

By M. Michael Miller

Domestic survey data and tables were prepared by Shonta E. Osborne, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2009, there was no primary fluorspar production in the United States, although a small amount of fluorspar was recovered as a byproduct of limestone quarrying in Illinois and was screened and sold as metallurgical grade. Fluorspar consumption decreased significantly in 2009 as a result of the continuing effects of the major economic downturn that began in late 2007 and extended through at least the first half of 2009. The bulk of U.S. consumption was supplied by imports and by small amounts of byproduct synthetic fluorspar produced from industrial waste streams. Byproduct fluorosilicic acid (FSA) production from some phosphoric acid producers supplemented fluorspar as a domestic source of fluorine but was not included in fluorspar production or consumption calculations.

According to the U.S. Census Bureau, U.S. trade in fluorspar, cryolite, and major fluorochemicals decreased significantly compared with that of 2008 (tables 1, 4–6). Fluorspar is used directly or indirectly to manufacture such products as aluminum, gasoline, insulating foams, plastics, refrigerants, steel, and uranium fuel. Most fluorspar consumption and trade involve either acid grade (also called acidspar), which is greater than 97% calcium fluoride (CaF_2), or subacid grade, which is 97% or less CaF_2. Subacid grade includes metallurgical and ceramic grades and is commonly called metallurgical grade or metspar.

Production

In 2009, small amounts of byproduct fluorspar were produced in Illinois. There is no U.S. Geological Survey (USGS) data survey for synthetic fluorspar. FSA is produced as a byproduct from the processing of phosphate rock into phosphoric acid. Domestic production data for FSA were developed by the USGS from a voluntary canvass of U.S. phosphoric acid operations known to recover FSA. Of the five FSA operations surveyed, responses were received from four plants, representing 93% of the total sold or used by producers. Production and sales data for the one nonrespondent were estimated based on prior year company data.

In 2009, there were three companies producing marketable byproduct FSA at phosphoric acid plants (part of a phosphate fertilizer operation). J.R. Simplot Co., Mosaic Fertilizer (a subsidiary of The Mosaic Co.), and PCS Phosphate Co. Inc. operated five plants in Florida, Louisiana, North Carolina, and Wyoming that produced marketable FSA. Production of byproduct FSA was 64,800 metric tons (t) (100% basis H_2SiF_6), and quantities sold or used totaled 64,700 t (equivalent to approximately 114,000 t of fluorspar grading 92% CaF_2) valued at about $10.6 million.

Some synthetic fluorspar was recovered as a byproduct of petroleum alkylation, stainless steel pickling, and uranium processing. The majority of the marketable product was estimated to come from uranium processing, but the actual amount of synthetic fluorspar recovered is unknown.

Hastie Mining and Trucking Co. (Cave-In-Rock, IL), Core Metals Group (Aurora, IN), and Seaforth Mineral & Ore Co. Inc. (East Liverpool, OH) marketed screened and dried imported acid- and metallurgical-grade fluorspar. Hastie Mining also screened and sold small amounts of byproduct fluorspar from the company's limestone quarry operation.

Hastie Mining continued development work on the Klondike II Mine project in Livingston County, KY. Construction of the tailings pond was completed, and work began on opening access to the vein ore body. The vein is about 7.6 meters (m) (25 feet) wide and extends for 1,220 m (4,000 feet) at a depth of about 61 m (200 feet), which was expected to allow relatively easy access by driving a decline into the ore body. It was expected that the ore body would be reached by late summer 2010 and that fluorspar production would begin by yearend or in early 2011. Output from the mine would be sent to Hastie's flotation mill near Salem in Crittenden County, KY. Hastie also has leased the mineral rights to an additional 486 hectares (1,200 acres) south of U.S. 60 in Livingston County between Burna and Salem (Crittenden Press, The, 2010; Boyce Moody, III, Moody Minerals Co., oral commun., March 5, 2010).

Environment

As a result of accidental releases of HF at three U.S. refineries in Illinois, Pennsylvania, and Texas, the United Steelworkers union (USW) has called for the phaseout of HF used in petroleum alkylation units at refineries. The USW (the largest industrial union in North America) planned to discuss alternatives to HF with the refining industry, and, if necessary, would work through the regulatory agencies and Congress to get the issue resolved. One-third of refineries use HF as an alkylation catalyst, while the other two-thirds use sulfuric acid, which is less dangerous because of its much lower vapor pressure. The USW also stated that it planned to work with local and national environmental groups to end the use of HF in alkylation (PR Newswire, 2009). Petroleum alkylation accounted for 14% of HF consumption in the United States in 2008 (Will, 2009, p. 85).

Consumption

Domestic consumption data were developed by the USGS from a quarterly consumption survey of two large consumers that provide data on HF consumption and four distributors that provide data on the merchant market (metallurgical and other uses). Quarterly data were received from all six respondents, and these responses accounted for 100% of the reported consumption in table 2.

Industry practice has established three grades of fluorspar—acid grade, containing more than 97% CaF_2; ceramic grade, containing 85% to 95% CaF_2; and metallurgical grade, normally containing 60% to 85% CaF_2. Fluorspar grades are defined by the intended use, but these grades are essentially just ranges derived from customer and supplier specifications. For reasons ranging from availability to economics to process changes, U.S. consumers have been moving toward the use of higher quality fluorspar. For example, welding rod manufacturers may use acid-grade fluorspar rather than ceramic grade, and some steel mills use ceramic or acid grade rather than metallurgical grade.

Total reported U.S. fluorspar consumption decreased by 21% in 2009 compared with that of 2008 (table 2). Because of the closure of the single aluminum fluoride (AlF_3) producer in 2008, consumption data for the two HF producers has been combined with "Other" uses in table 2 to avoid disclosing company proprietary data.

Acid-grade fluorspar, which accounted for 95% of the total U.S. fluorspar consumption, was used primarily as a feedstock in the manufacture of HF. Two companies reported fluorspar consumption for the production of HF in 2009, E.I. du Pont de Nemours & Co. Inc. (DuPont) and Honeywell International Inc. Fluorspar consumption for HF production decreased substantially compared with that of 2008. Since most acid-grade fluorspar is converted to HF before consumption, it is necessary to discuss HF uses and markets in order to properly analyze fluorspar consumption.

The leading use of HF was for the production of a wide range of fluorocarbon chemicals, including hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs), fluoroelastomers, and fluoropolymers. Production of these compounds accounted for about 75% of domestic HF consumption and 40% of world HF consumption. Major U.S. producers were Arkema Inc., DuPont, Great Lakes Chemical Corp., Honeywell, Mexichem Fluor, Inc. (formerly Ineos Fluor Americas LLC), MDA Manufacturing Ltd., and Solvay Solexis Inc.

Internationally, acid-grade fluorspar was used in the production of AlF_3 and cryolite (Na_3AlF_6), which are the main fluorine compounds used in aluminum smelting. Alumina is dissolved in a bath that consists primarily of molten Na_3AlF_6, AlF_3, and fluorspar to allow electrolytic recovery of aluminum. Fluorine losses are replaced entirely by the addition of AlF_3, the majority of which will react with excess sodium from the alumina to form Na_3AlF_6. Most AlF_3 is produced directly from acid-grade fluorspar or from byproduct FSA. The United States ceased production of AlF_3 in fall 2008 when Alcoa World Alumina LLC (a business unit of Alcoa Inc.) closed its Point Comfort, TX, production facility.

The merchant fluorspar market in the United States included sales of metallurgical- and acid-grade material mainly to steel mills, where it was used primarily as a fluxing agent to increase the fluidity of the slag. Sales were also made to smaller markets such as cement plants, foundries, glass and ceramics plants, and welding rod manufacturers in railcar, truckload, and less-than-truckload quantities. Complete data on merchant fluorspar sales cannot be shown because consumption of acid-grade fluorspar for HF production has been combined with other uses in table 2 to prevent disclosure of company proprietary data. In 2009, merchant sales (excluding acid-grade for other uses) decreased by 40% compared with those of 2008. During the past 20 to 30 years, fluorspar usage in such industries as steel and glass has declined because of product substitutions or changes in industry practices.

As a result of the recession, operating rates of U.S. steel mills decreased dramatically beginning in late 2008. In December 2008, raw steel capacity utilization dropped to 41%—its lowest point during the recession. It averaged less than 44% through the first 6 months of 2009, and it slowly increased during the second half of the year but still only averaged 62% in the fourth quarter (Fenton, 2009; 2010). In the United States, consumption of fluorspar in metallurgical markets (mainly steel) decreased by 44% compared with that of 2008. Consumption in this sector was 66% metallurgical grade and 34% acid grade. This large decrease parallels the decrease in U.S. raw steel production of 37%, from 91.9 million metric tons (Mt) in 2008 to 58.2 Mt in 2009 (M.D. Fenton, U.S. Geological Survey, written commun., April 16, 2010).

In the United States, FSA is used primarily for water fluoridation, but it may also be used as a metal surface treatment and cleaner and for pH adjustment in industrial textile processing or laundries. It can also be used in the processing of hides, for hardening masonry and ceramics, and in the manufacture of other chemicals. In 2009, byproduct FSA sold for water fluoridation was about 59,800 t valued at $9.28 million, and about 4,900 t valued at $1.3 million was sold or used for other uses.

Stocks

Data for stocks were available from some fluorspar distributors and HF and AlF_3 producers. Known consumer and distributor stocks at the end of 2009 totaled about 103,000 t. This represented a 10% decrease in known consumer and distributor stocks from the end of the previous year. The last sales from the National Defense Stockpile were made in 2006, and Government stocks of fluorspar were zero.

Transportation

The United States depends on imports for the majority of its fluorspar supply. Metallurgical-grade fluorspar is shipped routinely as lump or gravel, with the gravel passing a 75-millimeter (mm) sieve and not more than 10% by weight passing a 9.5-mm sieve. Acid grade is shipped in the form of damp filtercake that contains 7% to 10% moisture to facilitate handling and to reduce dust. This moisture is removed by heating the filtercake in rotary kilns or other dryers before treating with sulfuric acid to produce HF. Acid-grade imports from China and South Africa are usually shipped by ocean freight using bulk carriers of 10,000-t to 50,000-t deadweight capacity; ships in this size range are termed "handymax." Participants negotiate freight levels, terms, and conditions. Some acid grade and ceramic grade is marketed in bags for small users and shipped by truck.

Ocean freight rates were extremely low at the beginning of 2009, but did increase somewhat during the year. Peak rates in 2009, however, were still dramatically lower than the peak reached in the summer 2008. In January, the Baltic dry index (BDI) was well under 1,000, but edged up to about 3,000 by yearend (Stockcharts.com, 2010). The BDI tracks worldwide international shipping prices of handymax, panamax, and capesize dry bulk carriers.

Prices

In 2009, as a result of the sharp downturn in world demand for fluorspar, Chinese fluorspar prices decreased dramatically from their peak import price of $550 per metric ton in late 2008. According to published prices (Industrial Minerals, 2008; 2009), the 2009 yearend price range for Chinese acid-grade fluorspar (including cost, insurance, and freight at U.S. Gulf of Mexico ports, dry basis) had decreased by $175 per metric ton compared with that of yearend 2008. Prices of Mexican and South African acid grade did not change as dramatically because of shifts in purchase patterns and variations in product quality. For example, in 2009, the United States purchased more acid-grade fluorspar from Mexico, which helped stabilize its price in about the same range as it had been in 2008. However, the average range for low-arsenic Mexican acid grade, free on board (f.o.b.) Tampico, decreased by $80 per metric ton. The average price range of acid grade from South Africa, f.o.b. Durban, actually increased slightly, but this was primarily the result of the elimination of lower quality exports that sold at reduced prices. Adding some stability to prices was the closure of some fluorspar producers in Africa, which to some degree helped bring supply in balance with the reduced demand. Prices for metallurgical-grade fluorspar listed in table 3 were calculated from fourth-quarter statistics from the U.S. Census Bureau.

Foreign Trade

The European Union, Mexico, and the United States requested World Trade Organization (WTO) dispute settlement consultations with China regarding China's export restraints on numerous important raw materials including fluorspar. China is a leading global producer of these raw materials, and the dispute concerned China's policy that provided substantial competitive advantages for the Chinese industries using these raw material inputs to produce numerous downstream products in the steel, aluminum, and chemical sectors. Specific to fluorspar, China imposes quantitative restrictions in the form of export quotas, export license fees, and export taxes and has abolished value-added tax export rebates. Article XI:1 of the General Agreement on Tariffs and Trade states that "No prohibitions or restrictions other than duties, taxes or other charges, whether made effective through quotas, import or export licences [sic] or other measures, shall be instituted or maintained . . . on the exportation or sale for export of any product destined for the territory of any other contracting party." In addition, China's WTO Accession Protocol contained broad commitments not to restrict the right to export goods. As part of its WTO accession, China committed to eliminate export duties for all products other than those listed in a specific annex. Further, China committed to limit any export duties on the listed products to specified levels. The export duties being challenged were on products not listed in the annex or are imposed at rates that exceed the annex limits (Office of the United States Trade Representative, 2009).

The three petitioners held two rounds of dispute settlement consultations with China but failed to resolve the problem. Subsequently, each country requested that the WTO convene a dispute settlement panel to investigate and rule on the export restrictions. After China rejected the requests to establish the panel, the Dispute Management Body of the WTO established a single panel to examine the complaints (Chinadaily.com.cn, 2009; Gerson Lehrman Group, 2009; World Trade Organization, 2009).

In 2009, U.S. exports of fluorspar totaled 14,100 t, which was a decrease of 25% compared with those of 2008 (table 4). With the disposal of all fluorspar stocks in the National Defense Stockpile and only a small amount of mined fluorspar, exports are likely reexports of imported material. The leading recipients of U.S. exports were Canada (56%), Taiwan (28%), and Mexico (16%).

In 2009, imports for consumption of fluorspar decreased by 17% compared with those of 2008 (table 5). The leading suppliers of fluorspar to the United States were Mexico (67%), China (14%), South Africa (13%), and Mongolia (6%).

In 2009, responding to higher prices and reduced supply, U.S. consumers of acid-grade fluorspar continued to reduce purchases from China and replace them with increased purchases from Mexico and South Africa. This continued a trend that began in 2007. Mexico accounted for 62% of acidspar imports (50% in 2008, 41% in 2007); China, 16% (37% in 2008, 48% in 2007); and South Africa, 15% (11% in 2008, 7% in 2007).

Compared with those of 2008, imports of HF decreased by 14% to 114,000 t (table 6), imports of cryolite (Na_3AlF_6) decreased by 63% to 2,830 t (table 7), and imports of AlF_3 decreased by 61% to 18,700 t. The majority of HF imports were from Mexico (86%), with Canada and China supplying most of the balance. In 2009, the bulk of AlF_3 imports were from China (55%) and Canada (37%), with a small but significant amount from a newly opened AlF_3 plant in Mexico (More information can be found under World Review).

World Review

World fluorspar production decreased by about 9% compared with that of 2008. Much of the decrease was in the major exporting countries—China, Kenya, Namibia, and South Africa.

Canada.—Rivera Capital Corp. (North Vancouver, British Columbia) and Burin Fluorspar Ltd. (Alberta) announced that shareholders of both companies voted unanimously in favor of combining the two companies. The companies amalgamated, effective April 15, 2009, and began operating under the name Canada Fluorspar Inc. (Trading Markets.com, 2009).

Canada Fluorspar continued with plans to reopen the St. Lawrence Fluorspar Mine in Newfoundland. A significant development was the company's announcement of the completion of its NI 43–101 compliant technical report on the St. Lawrence property. According to the report, drilling was completed on two separate, identifiable vein resources, each of which had the potential to become a separate mine. The Blue Beach vein contained approximately 4.4 million Mt of indicated mineral resources at an average grade of 39.0% CaF_2. In addition, Blue Beach north vein contained approximately 355,000 t of inferred mineral resources at an average grade of 30.0% CaF_2. The Tarefare vein (and the associated Blowout vein) contained approximately 4.7 Mt of indicated mineral resources at an average grade of 44.8% CaF_2. The Blowout vein contained an additional 600,000 t of inferred mineral resources at an average grade of 31.8% CaF_2. Using a cutoff grade of 20% CaF_2 and minimum horizontal thickness of 2 m, the mineral resources of the St. Lawrence property totaled about 9.1 Mt of indicated mineral resources at an average grade of 42.0% CaF_2 and 950,000 t of inferred mineral resources at an average grade of 31.0% CaF_2 (CNW Group, 2009).

China.—At the same time as the WTO was investigating complaints against China's fluorspar export restrictions, China announced plans to restrict future production of fluorspar. Citing concerns over decreasing reserves and environmental pollution, Chinese authorities have been rejecting new exploration and production licenses for fluorspar. Additional actions included increasing the resource tax for fluorspar production to 15% and, as with many other industries, the Government was continuing its efforts to close down small and inefficient producers. Finally, the Chinese Government had reportedly abolished the export quota for fluorspar for 2010, since little or no bidding for quota volumes had taken place (Globe Metals & Mining, 2010; Russell, 2010).

Kenya.—Kenya Fluorspar Company Ltd. (KFC) ceased production from its fluorspar mine in the Kerio Valley. Demand for the company's acid-grade fluorspar had dropped by more than 70% compared with that of 2008, when the company exported 106,000 t of fluorspar to its customers in Asia and Europe. KFC had accumulated stocks of more than 15,000 t at its flotation plant at the time of the shutdown in March. The closure had a severe impact on the local economy since KFC employed 500 workers directly and was the most important economic enterprise in the district (Bii, 2009).

Mexico.—Despite the global economic downturn, Mexico's fluorspar production increased slightly compared with that of 2008. Exports of acid-grade fluorspar were 361,000 t or nearly the same level as in 2008. Metallurgical-grade fluorspar exports, however, decreased by about 37% to 244,000 t reflecting the large decrease in world steel output.

As part of its expansion into downstream, higher-value products, Mexico's leading fluorspar producer, Mexichem S.A.B. de C.V., opened an AlF_3 plant in Matamoros, Tamaulipas. The 60,000-metric-ton-per-year plant will operate as part of the Mexichem Fluor division of Mexichem and was expected to primarily supply export markets (Mexichem S.A.B. de C.V., 2009). Indicative of this increase in exports, Mexico's exports of AlF_3 to the United States increased to 1,460 t in 2009 from 1 t in 2008 to (table 8).

In August, Mexico joined the United States and the European Union when it also filed a complaint with the WTO over China's export restrictions. The complaint requested formal WTO consultations; China had 30 days to respond to Mexico's request for trade consultations; otherwise, Mexico could request an arbitration panel (Kiernan, 2009).

Mongolia.—Lotus Resources plc (London, United Kingdom) signed four joint-venture agreements with partners in Mongolia for the exploration and development of fluorspar deposits. The agreements included the formation of Lotus Dai Uul LLC and Lotus Ambuulan LLC. Lotus Dai Uul began sales of metallurgical-grade fluorspar through MGB Mining LLC (Mongolia) to customers in Russia, and the mining license in Dornogobi Province was successfully transferred to Lotus Ambuulan in July. After approval of an environmental assessment and mining plan, open pit mining was expected to begin almost immediately (Lotus Resources plc, 2009).

Namibia.—Okorusu Fluorspar (Pty.) Ltd. (Namibia) suspended fluorspar production for several months from August until late fall in order to draw down excessive stocks that accumulated owing to a decrease in sales of approximately 50% compared with those of 2008. Okorusu produced acid-grade fluorspar for its parent company Solvay S.A. (Belgium), which used it to produce HF at its plants in Germany and Italy. Solvay's 2009 fluorspar requirements from Okorusu were projected to be only about 56,000 t of fluorspar compared with a recent year figure of 109,000 t (Kaira, 2009; O'Driscoll, 2009).

South Africa.—South African fluorspar producer Sallies Ltd. (Pretoria), which mothballed its Buffalo Mine in the fourth quarter of 2008, was forced to suspend mining at its primary fluorspar mine—Witkop Fluorspar Mine (Pty.) Ltd.—owing to the dramatic decrease in demand for acid-grade fluorspar. The mine was mothballed in June when the company was unable to secure future orders from its customers. According to the company, the mine had already produced sufficient fluorspar to meet its contractual obligations through yearend 2009 (Miningreview.com, 2009).

A decision was handed down in the supply contract dispute between Sallies and Honeywell International (Morristown, NJ) that dates to 2006. The International Chamber of Commerce International Court of Arbitration in Switzerland ruled that fluorspar producer Sallies had to pay R11.5 million ($1.24 million) plus interest to Honeywell. The amount awarded was significantly lower than either the R65 million originally claimed by Honeywell or the R42 million claimed by Sallies in its countersuit (Schumacher, 2009). Subsequent to the decision, Sallies requested that the Federal Supreme Court of Switzerland review the Court of Arbitration's finding against it. As part of its request, Sallies asked the Swiss Supreme Court to instruct the Court of Arbitration to reject Honeywell's claim and to approve Sallies counterclaim (Creamer, 2009).

Sephaku Holdings Ltd. (South Africa) completed a definitive feasibility study on its proposed Nokeng Fluorspar Mine in South Africa's Gauteng Province. The study called for the development of two separate deposits—the Outwash Fan (formerly described as Naauwpoort/Kromdraai) and the Plattekop deposits—both of which are in the vicinity of Vergenoeg Mining Co. (Pty.) Ltd.'s fluorspar mine. The proposed mine complex would include an open pit mine, a 130,000-metric-ton-per-year flotation mill, tailings disposal facility, and associated infrastructure and services. Ore production was scheduled to begin in the spring of 2012 (Swanepoel, 2009). The two deposits have a combined measured resource of 12 Mt, which would be used to feed a blend of ore to the flotation mill at 32% CaF_2 average feed grade (Mineweb, 2008).

Metorex Ltd. (Johannesburg) announced that it was selling its 55% share in Vergenoeg Mining to Spanish fluorspar producer Minerales y Productos Derivados S.A. (Minersa). Minersa already owned a 30% stake in Vergenoeg, with the remaining 15% owned by Medu Capital, a consortium of Black Economic Empowerment-controlled entities (Metorex Ltd., 2009).

Eurasian Natural Resources Corp. Plc (United Kingdom) agreed to purchase Central African Mining and Exploration Co. (London, United Kingdom), which owned, among other properties, a 51% interest on the South African Doornhoek fluorspar project, which comprises the Doornhoek property and five other farms in the immediate vicinity. Eurasian Natural Resources is the holding company of a leading diversified natural resources group principally based in Kazakhstan (Frean, 2009). Results from a previously completed scoping study on the Doornhoek fluorspar project reported an indicated and inferred resource of about 30 Mt at 20% CaF_2. This potential was identified by historical drilling and was not compliant with any modern reporting code. The ore grade of the underground ore body is low, but is roughly 40% higher than that of the adjoining idle Witkop Fluorspar Mine (Londonstockexchange.com, 2009).

Sweden.—Tertiary Minerals plc (Macclesfield, United Kingdom) continued to evaluate its Storuman fluorspar deposit. Metallurgical testwork on fluorspar samples from the deposit successfully produced a fluorspar concentrate to a specification that would be salable to consumers of acid-grade fluorspar with respect to both chemical and grain-size specifications. This was considered important because previous testwork carried out in the 1970s produced fluorspar with acceptable chemical specifications, but only on samples that were ground to a grain size that was too fine for use in most HF plants (Tertiary Minerals plc, 2009a). Preliminary information from the company's scoping study estimated a potential fluorspar resource of 28 to 31 Mt grading 11.2% to 12.3% CaF_2. The estimates were based on the incomplete records of 39 drill holes from the 1970s and data from 10 confirmation drill holes completed in 2008 by Tertiary Minerals, mostly within the same area (Tertiary Minerals plc, 2009b).

Outlook

In the short term, the demand for fluorspar in the United States (and other countries whose economies were severely affected by the global economic downturn) depends on how quickly the world economy recovers. Consumption in China and India was expected to continue to increase although at a slightly slower pace than before the economic downturn.

Long-term demand for fluorspar may depend to a large degree on the competition for the future refrigeration market between fluorochemical and not-in-kind systems (ammonia, carbon dioxide, hydrocarbons, and so forth). Fluorocarbons developed to replace ozone-depleting CFCs have high global warming potential (GWP) and are being targeted for phaseout as part of an international response to climate change. Faced with the pending phaseout of HFC-134a in automotive air-conditioning systems in the European Union, fluorochemical producers Du Pont and Honeywell developed a likely new drop-in replacement with low GWP—hydrofluoroolefin HFO-1234yf. Another compound, HFO-1234ze, is being tested as a replacement in aerosols, foam blowing, and refrigeration. These two compounds each have low GWP and rapidly break down in the atmosphere.

Development of new fluorspar mine projects or work on reopening long-idle mines has been slowed by the global economic downturn, which resulted in both decreased demand for fluorspar and reduced availability of project funding. With China continuing to reduce its fluorspar exports, long-term supplies of fluorspar are expected to come from countries such as Mexico, Mongolia, and South Africa, all of which have large fluorspar resources that provide the potential for development of multiple new mining operations or the expansion of existing operations. Additional material will likely be supplied by other countries with smaller resources, but with single mine projects underway such as in Canada, Sweden, the United States, and Vietnam.

Major markets for fluorspar in developed countries have been stagnant or have decreased as first HF and more recently fluorocarbon production has moved to China, and aluminum smelting capacity has moved to countries or regions with access to less expensive energy. This shift is evident in the growing capacity in China and the reduced capacities in traditional production areas in Europe, Japan, and North America. China is already the world's leading fluorspar consumer and its share of global consumption will likely continue to increase in the future. China still possesses large fluorspar resources, but it is conceivable that China may find it necessary or expedient to become a net importer of fluorspar in the not too distant future.

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TABLE 1

SALIENT FLUORSPAR STATISTICS[1, 2]

		2005	2006	2007	2008	2009
United States:						
Exports:[3]						
Quantity	metric tons	36,100	13,000	13,600	18,800	14,100
Value[4]	thousands	$7,840	$2,430	$2,650	$3,340	$2,230
Imports:[3]						
Quantity	metric tons	629,000	553,000	620,000	572,000	475,000
Value[5]	thousands	$122,000	$112,000	$111,000	$133,000	$105,000
Average value:[5]						
Acid grade	dollars per metric ton	202	217	(6)	(6)	(6)
Metallurgical grade	do.	93	101	111	107	109
Consumption:						
Reported	metric tons	582,000	523,000	539,000	506,000	400,000
Apparent[7]	do.	616,000	607,000 r	613,000	529,000	473,000
Stocks, December 31:						
Consumer and distributor	do.	131,000 [8]	89,900 [8]	90,100	115,000	103,000
Government stockpile	do.	35,200	8,110	1,450	--	--
World, production	do.	5,360,000 r	5,660,000 r	5,720,000 r	5,990,000 r	5,460,000 e

e Estimated r Revised. do. Ditto. -- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Does not include fluorosilicic acid production or imports of hydrofluoric acid and cryolite.

[3] Source: U.S. Census Bureau; data may be adjusted by the U.S. Geological Survey.

[4] Free alongside ship values at U.S. ports.

[5] Average unit value for the year, includes cost, insurance, and freight values at U.S. ports.

[6] Value data for acid-grade fluorspar imports appear to be underreported; accurate average value calculations cannot be made.

[7] Imports minus exports plus adjustments for changes in stocks held by Government and three leading consumers.

[8] Includes fluorspar purchased from the National Defense Stockpile (NDS) but still located at NDS depots.

TABLE 2

U.S. REPORTED CONSUMPTION OF FLUORSPAR, BY END USE[1]

(Metric tons)

End use or product	Containing more than 97% calcium fluoride		Containing not more than 97% calcium fluoride		Total	
	2008	2009	2008	2009	2008	2009
Hydrofluoric acid and aluminum fluoride	429,000	W	--	--	429,000	W
Metallurgical	14,900	9,390	33,800	17,900	48,700	27,200
Other[2]	28,700	371,000	--	2,030	28,700	373,000
Total	472,000	380,000	33,800	19,900	506,000	400,000
Stocks, consumer, December 31	94,300	87,200	20,500	15,600	115,000	103,000

W Withheld to avoid disclosing company proprietary data; included in "Other." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] May include cement, enamel, glass and fiberglass, steel castings, welding rod coatings, and hydrofluoric acid (2009).

TABLE 3
PRICES OF IMPORTED FLUORSPAR

(Dollars per metric ton)

Source and grade	2008	2009
Acidspar:		
Chinese, dry basis, cost, insurance, and freight (c.i.f.) Gulf port, filtercake	530–550	350–380
Mexican, free on board (f.o.b.) Tampico, filtercake	250–325	260–290
Mexican, f.o.b. Tampico, arsenic <5 parts per million	400–420	300–360
South African, f.o.b. Durban, filtercake	250	250–300
Metspar, Mexican, c.i.f. port of U.S. entry, metspar[1]	108	97

[1] Metspar prices are the average value per metric ton of imported Mexican metspar for the fourth quarter calculated from the U.S. Census Bureau statistics.

Sources: Industrial Minerals, no. 495, December 2008, p. 88; no. 507, December 2009, p. 68.

TABLE 4
U.S. EXPORTS OF FLUORSPAR, BY COUNTRY[1]

	2008		2009	
Country	Quantity (metric tons)	Value[2]	Quantity (metric tons)	Value[2]
Australia	15	$7,200	6	$3,840
Brazil	22	3,120	--	--
Canada	4,870	1,270,000	7,900	1,260,000
China	4,280	621,000	--	--
Dominican Republic	524	95,000	--	--
India	24	7,000	--	--
Indonesia	5	2,860	--	--
Israel	15	4,500	--	--
Korea, Republic of	72	18,000	--	--
Malaysia	15	9,630	6	3,660
Mexico	29	3,200	2,320	394,000
Netherlands	30	4,400	--	--
Philippines	161	18,000	--	--
Taiwan	8,780	1,280,000	3,890	564,000
Total	18,800	3,340,000	14,100	2,230,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship values at U.S. ports.

Source: U.S. Census Bureau.

TABLE 5

U.S. IMPORTS FOR CONSUMPTION OF FLUORSPAR, BY COUNTRY AND CUSTOMS DISTRICT[1]

	2008		2009	
Country and customs district	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Containing more than 97% calcium fluoride (CaF_2):				
China:				
Cleveland, OH	3,720	$1,540	--	--
Great Falls, MT	6	15	319	$38
Houston, TX	117,000	39,100	45,100	15,000
Los Angeles, CA	--	--	103	13
New Orleans, LA	63,200	26,400	21,600	9,210
Seattle, WA	--	--	234	31
Total	184,000	67,100	67,300	24,300
Germany, Savannah, GA	133	17	--	--
Mexico:				
Baltimore, MD	--	--	536	241
Laredo, TX	74,100	18,600	42,100	12,900
New Orleans, LA	175,000	23,400	217,000	33,100
Total	249,000	42,000	260,000	46,200
Mongolia:				
Houston, TX	--	--	28,600	8,590
New Orleans, LA	5,500	2,100	--	--
Total	5,500	2,100	28,600	8,590
Russia, Philadelphia, PA	1	7	--	--
South Africa:				
Great Falls, MT	258	106	--	--
Houston, TX	51,100	12,000	38,800	11,800
New Orleans, LA	5,360	1,960	22,000	7,300
Total	56,700	14,100	60,800	19,100
United Kingdom:				
Houston, TX	55	51	130	17
Los Angeles, CA	588	69	446	52
Total	643	120	576	70
Grand total	496,000	125,000	417,000	98,300
Containing not more than 97% CaF_2:				
Mexico:				
Cleveland, OH	--	--	1	5
Laredo, TX	5,100	522	4,430	448
New Orleans, LA	70,100	7,510	52,900	5,810
Total	75,200	8,040	57,300	6,260
Namibia:				
Charleston, SC	283	26	--	--
Houston, TX	519	45	203	24
Total	802	71	203	24
Grand total	76,000	8,110	57,500	6,290
Grand total, all grades	572,000	133,000	475,000	105,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight values at U.S. ports.

Source: U.S. Census Bureau; data may be adjusted by the U.S. Geological Survey.

TABLE 6

U.S. IMPORTS FOR CONSUMPTION OF HYDROFLUORIC ACID, BY COUNTRY[1]

	2008		2009	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Canada	23,900	$48,400	11,000	$39,500
China	1,690	2,430	4,110	4,270
France	(3)	2	--	--
Germany	562	1,420	404	1,250
Hong Kong	--	--	33	39
India	71	142	120	164
Japan	1,240	2,520	559	1,180
Liechtenstein	1	90	--	--
Lithuania	--	--	(3)	9
Mexico	105,000	117,000	97,600	114,000
Singapore	79	209	64	211
South Africa	--	--	13	22
Spain	--	--	(3)	3
Switzerland	--	--	(3)	2
Taiwan	34	133	49	134
United Kingdom	(3)	5	(3)	3
Total	133,000	172,000	114,000	161,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight values at U.S. ports.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7

U.S. IMPORTS FOR CONSUMPTION OF CRYOLITE, BY COUNTRY[1]

	2008		2009	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Canada	398	$118	5	$14
China	1,590	1,460	498	357
Denmark	450	416	151	288
Germany	2,280	2,440	878	1,330
Hungary	345	382	250	346
India	1	9	--	--
Japan	2,450	3,200	860	1,070
Mexico	--	--	81	30
Turkey	20	4	--	--
United Kingdom	120	160	103	195
Other	-- r	-- r	--	--
Total	7,650	8,180	2,830	3,630

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight values at U.S. ports.

Source: U.S. Census Bureau.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM FLUORIDE, BY COUNTRY[1]

Country	2008		2009	
	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Canada	15,400	$21,100	6,950	$11,000
China	28,900	44,500	10,200	14,500
Italy	102	149	--	--
Japan	65	201	(3)	4
Mexico	1	9	1,460	1,280
Other[4]	3,100	3,400	45	95
Total	47,600	69,400	18,700	26,800

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight values at U.S. ports.

[3] Less than ½ unit.

[4] Includes Brazil (2008), Germany, India (2009), the Netherlands (2009), Sweden, Switzerland (2008), and the United Kingdom (2008).

Source: U.S. Census Bureau.

TABLE 9
FLUORSPAR: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country and grade[3, 4]	2005	2006	2007	2008	2009[e]
Argentina	7,502	8,278	9,735	15,098[r]	15,000
Brazil, marketable:					
Acid grade	42,043	41,373	44,869	45,342[r]	44,559
Metallurgical grade	24,469	22,231	20,582[r]	19,014[r]	19,500[p]
Total	66,512	63,604	65,451[r]	64,356[r]	64,059
China:[e]					
Acid grade	1,650,000	1,800,000	1,850,000	1,900,000	1,600,000
Metallurgical grade[5]	1,150,000	1,300,000	1,350,000	1,350,000	1,300,000
Total	2,800,000	3,100,000	3,200,000	3,250,000	2,900,000
Egypt	549	550[e]	1,080[r]	470[r]	500
France:[e, 6]					
Acid and ceramic grades	80,000	35,000	--	--	--
Metallurgical grade	10,000	5,000	--	--	--
Total	90,000	40,000	--	--	--
Germany, acid grade	35,364	53,009	54,359	48,519[r]	45,000
India:[e, 7]					
Acid grade	4,400	500	1,000	1,500	1,600
Metallurgical grade	6,500	5,800	5,000	5,500	5,600
Total	10,900	6,300	6,000	7,000	7,200
Iran[8]	64,601	65,000	68,192[r]	65,000[e]	65,000
Italy[6]	15,000	8,000	--	--	--
Kazakhstan[e]	4,750[9]	30,000	64,000[9]	66,300	67,000
Kenya, acid grade	97,261	83,428	82,000	98,248	15,667
Korea, North, metallurgical grade[e]	--[r]	--[r]	--[r]	--[r]	--
Kyrgyzstan[e]	4,000	4,000	4,000	4,000	4,000
Mexico:[e, 10]					
Acid grade	324,568[9]	466,000[9]	513,000	630,000	630,000
Metallurgical grade	550,882[9]	470,000[9]	420,000	428,000	410,000
Total	875,450[9]	936,000[9]	933,000	1,060,000	1,040,000
Mongolia:[11]					
Acid grade[12]	93,700[r]	108,300[r]	109,900	115,700	115,300
Other grades	233,400	239,400[r]	245,000[r]	219,100[r]	344,200
Total	327,100[r]	347,700[r]	354,900[r]	334,800[r]	459,500
Morocco, acid grade	114,740	94,254	78,900	60,700	75,000
Namibia, acid grade[13]	105,700	121,700	109,300[r]	108,800[r]	73,580
Pakistan, metallurgical grade[e]	1,040	2,839[9]	1,500	1,400	1,300
Romania, metallurgical grade[e]	15,000	15,000	15,000	15,000	15,000
Russia[e]	245,500[9]	210,000	180,000	269,000	240,000
South Africa:[e, 14]					
Acid grade	250,000	240,000	268,000	281,000[r]	196,000
Metallurgical grade	16,000	16,000	17,000	18,000[r]	8,000
Total	266,000	256,000	285,000	299,000[r]	204,000
Spain:					
Acid grade	133,495	135,864	132,753	133,000	125,000
Metallurgical grade	10,500	17,241	16,279	16,300	15,000
Total	143,995	153,105	149,032	149,300	140,000
Tajikistan[e]	8,500	8,500	8,500	8,500	8,500
Thailand, metallurgical grade	295	3,240	1,820	29,529[r]	3,000
United Kingdom[15]	56,417[r]	49,676[r]	44,936[r]	36,801[r]	18,536
Grand total	5,360,000[r]	5,660,000[r]	5,720,000[r]	5,990,000[r]	5,460,000

See footnotes at end of table.

TABLE 9—Continued
FLUORSPAR: WORLD PRODUCTION, BY COUNTRY[1, 2]

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[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 25, 2010.

[3] In addition to the countries listed, Bulgaria is thought to have produced fluorspar in the past, but production is not officially reported, and available information is inadequate for the formulation of reliable estimates of output levels.

[4] An effort has been made to subdivide production of all countries by grade (acid, ceramic, and metallurgical). Where this information is not available in official reports of the subject country, the data have been entered without qualifying notes.

[5] Includes submetallurgical-grade fluorspar used primarily in cement that may account for 33% to 50% of the quantity.

[6] Mine closed in 2006.

[7] Year beginning April 1 of that stated.

[8] Year beginning March 21 of that stated. Data for 2005 is reported by Iranian Mines and Mining Development and Renovation Organization.

[9] Reported figure.

[10] Data are reported by Servicio Geológico Mexicano, quantities by grade may be estimated.

[11] Data are reported by Mineral Resource Authority of Mongolia.

[12] Flotation concentrate, including less than 97% CaF_2 material.

[13] Data were in wet tons, but have been converted to dry tons to agree with other data in table.

[14] Based on data from the South African Minerals Bureau; data show estimated proportions of acid-, ceramic-, and metallurgical-grade fluorspar within the reported totals.

[15] Data are reported by British Geological Survey.

GALLIUM

By Brian W. Jaskula

Domestic survey data and tables were prepared by Lisa Mersdorf, statistical assistant.

In 2009, no domestic production of primary gallium was reported and gallium metal and gallium arsenide (GaAs) wafer imports continued to account for most of the U.S. gallium consumption. Metal imports were 13% lower than those in 2008, with Canada, Germany, the United Kingdom, and China, in descending order of imports by gallium content, as the leading sources of imported gallium. Doped GaAs wafer imports were 29% lower than those in 2008; Germany and Japan were the principal sources. Almost all gallium consumed in the United States was in the form of GaAs and gallium nitride (GaN) and was used in integrated circuits (ICs) and optoelectronic devices [laser diodes, light-emitting diodes (LEDs), photodetectors, and solar cells]. Gallium consumption decreased by 13% from that in 2008. In 2009, gallium consumed in the United States was less than the gallium imported because a large portion of the U.S. imports was estimated to be low-purity material that was refined in the United States and shipped to other countries.

In 2009, estimated world crude gallium production was 79 metric tons (t), 29% lower than that in 2008. Principal producers were China, Germany, Kazakhstan, Russia, and Ukraine. Plants in Hungary, Japan, and Slovakia also recovered gallium. Refined gallium production was estimated to be about 122 t, which included some new scrap refining. Refined gallium was produced in China, Japan, the United Kingdom, and the United States.

Legislation and Government Programs

The U.S. Department of Energy (DOE) awarded $6.4 million to four research projects focused on improving green LEDs and organic blue emitters. Of the total, $4.6 million was provided via the American Recovery and Reinvestment Act (ARRA). These projects continued the DOE's effort to advance state-of-the-art solid-state lighting (SSL) used for general lighting applications. The award recipients included the National Renewable Energy Laboratory, the Pacific Northwest National Laboratory, Sandia National Laboratories, and the U.S. Army Laboratory (Semiconductor Today, 2009i). The DOE also announced that $50 million of ARRA funding had been allocated for additional SSL research and development (LEDs Magazine, 2009b).

Northrop Grumman Corp. (Los Angeles, CA) and TriQuint Semiconductor, Inc. (Hillsboro, OR) were respectively awarded $28.9 million and $16.2 million Defense Advanced Research Projects Agency (DARPA) multiyear contracts to create high-dynamic-range digital GaN circuits for future defense and aerospace applications. The contracts support the first phase of DARPA's Nitride Electronic NeXt-Generation Technology (NEXT) program. Digital GaN circuits, unlike analog GaN circuits, have the potential to increase operating frequencies while simultaneously employing very high breakdown voltages. The NEXT circuit design was expected to lead to dramatic improvements in the performance of radio frequency (RF) and mixed-signal electronic circuits and was expected to fundamentally improve performance in U.S. military and space applications (Northrop Grumman Corp., 2009; TriQuint Semiconductor, Inc., 2009).

Production

No domestic production of primary gallium was reported in 2009 (table 1). Recapture Metals Inc. (Blanding, UT) recovered gallium from scrap materials, predominantly those generated during the production of GaAs. Recapture Metals' facilities have the capability to produce about 40 metric tons per year (t/yr) of high-purity gallium. The company recovered gallium from its customers' scrap on a fee basis and purchased scrap and low-purity gallium for processing into high-purity material.

In August, Recapture Metals was acquired by Neo Performance Materials Ltd. (Toronto, Ontario, Canada), a producer and processor of magnetic powders, and rare earth and zirconium-based engineered materials. As a wholly owned subsidiary of Neo Performance Materials, Recapture Metals retained its name (Metal-Pages, 2009b).

Consumption

Gallium consumption data were collected by the U.S. Geological Survey from a voluntary survey of U.S. operations. In 2009, there were 11 respondents to the consumption of gallium survey, representing 61% of the total canvassed. Data in tables 2 and 3 were adjusted by incorporating estimates to reflect full industry coverage. Many of these estimates were based on company 2009 10–K reports submitted to the U.S. Securities and Exchange Commission.

More than 99% of the gallium consumed in the United States was in the form of GaAs or GaN. GaAs was used to manufacture optoelectronic devices (laser diodes, LEDs, photodetectors, and solar cells) and ICs. ICs accounted for 74% of domestic consumption, optoelectronic devices accounted for 25%, and 1% was used in research and development and other applications (table 2). GaN principally was used to manufacture LEDs and laser diodes.

In 2009, U.S. consumption of gallium for use in ICs was not significantly affected by the global economic downturn and remained relatively flat compared with that of 2008. Gallium use in LEDs and laser diodes increased by 41% from that of 2008 owing to the exceptional growth in demand from the LED industry beginning in the third quarter of 2009. Gallium suppliers to the photodetector and solar cell industry were affected in 2009 by the economic downturn. U.S. gallium consumption decreased by 83% compared with that of 2008, as photodetector and solar cell customers did not restock in 2009.

Gallium Arsenide.—In 2009, the value of worldwide GaAs device consumption remained approximately flat compared with that of 2008 at $3.7 billion. Following a 5% decline in consumption during the first half of 2009, the GaAs device market rebounded strongly in the second half of the year owing to the strong growth of GaAs-rich third-generation (3G) and fourth-generation (4G) "smartphones" (cellular telephones with advanced personal computer-like functionality). These devices use up to four times the amount of GaAs of previous generations of cellular telephones. In 2009, smartphone market sales increased by 15% from those of 2008 (Bernhardt, 2010; Semiconductor Today, 2010b).

Sumika Electronic Materials Inc. (Phoenix, AZ) met increasing GaAs epiwafer demand by increasing production capacity of its Phoenix GaAs epiwafer foundry with the installation of an additional Aixtron 2600 G3 epi reactor (Sumika Electronic Materials Inc., 2009).

To also meet growing GaAs wafer demand, EpiWorks Inc. (Champaign-Urbana, IL) announced plans to increase its 6-inch GaAs wafer production capacity to 100,000 wafers per year by yearend 2009. The company had previously boosted its 6-inch wafer production capacity to 50,000 wafers per year in 2007 (Semiconductor Today, 2009d).

Gallium Nitride.—Increased demand for GaN device applications, namely laser diodes, power electronics, and RF electronics, has provided significant growth opportunities for advanced GaN-based products. GaN power management applications, in particular, have shown much promise. GaN power transistors operate at higher voltages and with a higher power density than current GaAs devices. GaN power transistors and amplifiers have allowed microwave designers to reduce heat sink requirements and part counts, enabling smaller systems with higher performance and greater efficiency. The key drivers of this emerging GaN-based technology have been military and defense applications.

In September, scientists at the Massachusetts Institute of Technology (MIT) (Cambridge, MA) successfully integrated GaN with silicon to create a hybrid microchip that was expected to be smaller, faster, and more efficient than current silicon-based microprocessors. The MIT scientists anticipated that the new integration process would enable circuit and system designers to choose the best semiconductor material for each device in the microchip rather than having to compromise by using only one material for all the circuits (Savage, 2009).

In October, IQE plc (St. Mellons, United Kingdom) acquired United Kingdom-based GaN substrate firm NanoGaN Ltd. NanoGaN had previously established a range of processes and intellectual property relating to GaN materials and devices, including its proprietary nanocolumn technology for producing high quality, free-standing GaN substrates. The substrates were used in the manufacture of high-quality blue and green semiconductor lasers and ultrahigh brightness LEDs for SSL (Huang, 2009).

RF Micro Devices, Inc. (RFMD) opened its GaN foundry service in Greensboro, NC, and indicated that its GaN technology was to be targeted at high-power applications rather than lower-power, higher-frequency applications. The company's GaN manufacturing technology was to be housed in the same facility as its GaAs products (Semiconductor Today, 2009g).

Collaboration between Aixtron AG of Aachen, Germany, and SemiLEDs Corp. of Boise, ID, resulted in successful fabrication of GaN-based blue LED chips on 6-inch sapphire wafers. Mass manufacturing capability of blue LEDs was previously limited to 2-inch and 4-inch wafers. Approximately 10,000 LED chips can be processed simultaneously on a 2-inch wafer, while 90,000 LED chips can be processed simultaneously on a 6-inch wafer, thereby offering potentially significant cost savings in the manufacture of blue LEDs (Semiconductor Today, 2009a).

Light-Emitting Diodes.—Despite the global economic downturn, the worldwide high-brightness (HB) LED market increased to $5.4 billion in 2009, a 6% increase from $5.1 billion in 2008. HB LEDs experienced record growth in the second half of 2009 as a result of the rapid shift to LEDs in computer notebook displays and liquid crystal display (LCD) televisions using LED-based backlighting. LED-based backlighting allows for lighter and thinner screens, higher color saturation, and lower power consumption compared with traditional cold-cathode fluorescent lamp backlighting sources. Research and consulting firm IMS Research indicated that 46% of all computer notebooks rapidly shifted to LEDs in 2009, up from only 6% in 2008. Approximately 3% of all LCD televisions used LED backlighting in 2009, up from virtually none in 2008 (Semiconductor Today, 2009f, 2010c; Young, 2010).

In addition to LED-based backlighting applications, many general lighting projects were also addressed by LED lighting, including installations in hotels and casinos, municipal lighting, parking garages, and retail establishments. LED lighting allowed for greater energy efficiency, longer lifespan, and improved quality of light (Steele, 2010).

Research and consulting firm Strategy Analytics Inc. listed the main global segments for LEDs in 2009 as follows: signage, displays, and signaling, 37%; cellular and other mobile appliances, 30%; general illumination, 22%; automotive, 8%; and front-projection television and other backlighting, 3% (Young and Low, 2009). Total worldwide consumption of LEDs rose by 10.5% to 63 billion units in 2009 from 57 billion units in 2008. LED consumption in 2009 approached the industry's total capacity of 75 billion units, an 84% utilization rate (Semiconductor Today, 2010e).

LED firms began expanding their manufacturing capacities in 2009 in response to the growing popularity of LED backlighting and general LED lighting applications. Semiconductor Equipment and Materials International (SEMI) of San Jose, CA, indicated that seven new LED fabrication plants came online in 2009. SEMI announced that the region with the greatest number of LED fabrication plants was Taiwan (40%), followed by Japan (23%), and China (22%) (Semiconductor Today, 2010d).

Solar Cells.—Sustained high energy prices continued to spark interest in solar energy. Most of the solar cells that were manufactured for terrestrial applications were thin-film multijunction cells, with a substrate of germanium and layers of gallium indium arsenide and other gallium compounds. A lightweight, flexible, durable, and low-cost thin-film photovoltaic technology, copper indium gallium selenide (CIGS), has recently entered the printed solar cell market. CIGS modules can be directly integrated into building materials, consumer electronics for portable power, space applications, or configured as stand-alone modules for large-scale terrestrial deployment.

Research and consulting firm Displaybank Co., Ltd. (Bundang, Republic of Korea) reported that CIGS was the fastest growing technology within the printed solar cell market. In 2009, the worldwide CIGS market was valued at $96 million and increased by 81% from that of 2008. In 2010, the worldwide CIGS market was estimated to grow to $240 million, a 150% increase from that of 2009 (Displaybank Co., Ltd., 2009).

Several records for solar cell efficiency were achieved in 2009. Spectrolab Inc. (Sylmar, CA) (a wholly owned subsidiary of The Boeing Co.) set a world record for terrestrial concentrator solar cell efficiency with a photovoltaic device that converted greater than 41% of the light that hit it into electricity. The solar cell incorporated improvements in wafer processing that raised the cell's overall efficiency. Additionally, Global Solar Energy Inc. (Tucson, AZ) achieved a record 15.45% efficiency for its CIGS thin film solar cell. The company's CIGS material used a flexible substrate that allowed it to be lightweight, flexible, and durable, unlike traditional solar panels which tend to be heavy, rigid, and fragile. Both solar cell efficiency records were verified by the DOE's National Renewable Energy Laboratory (Boeing Co., The, 2009; Metal-Pages, 2009a).

In September, Solyndra Inc. (Fremont, CA) began construction of its second CIGS photovoltaic panel manufacturing plant. The plant was designed for an annual production capacity of 500 megawatts (MW) and was scheduled to open in late 2010. Solyndra's photovoltaic system was engineered to generate considerably more solar electricity from conventional low-slope commercial rooftops while having lower installation costs than standard photovoltaic flat-panel technologies. The cylindrical shape allows sunlight to be captured across a 360° photovoltaic surface capable of converting direct, diffuse, and reflected sunlight into electricity. Conventional flat-surfaced solar panels typically offer poor collection of diffuse light and fail to collect reflected light from installation surfaces (Semiconductor Today, 2009b).

Prices

Since 2002, producer prices for gallium have not been quoted in trade journals. Data in table 4 represent the average customs value of gallium imported into the United States. Reports in Mining Journal indicated that low-grade gallium prices decreased in 2009. At the beginning of the year, the low-grade gallium price was reported to be about $450 per kilogram. By August, the price had decreased to about $400 per kilogram. By December, the price had decreased to about $350 per kilogram.

From U.S. Census Bureau import data, the annual average value for low-grade (99.99%-pure) gallium was estimated to be $304 per kilogram, 16% lower than the estimated average value for 2008. For high-grade (>99.99%-pure) gallium, the annual average estimated value decreased to $449 per kilogram, about 22% lower than that in 2008. Import data reported by the U.S. Census Bureau do not specify purity, so the values listed in table 4 were estimated based on the average value of the material imported and the country of origin.

Foreign Trade

In 2009, U.S. gallium imports were 13% lower than those in 2008 (table 5). Canada (29%), Germany (20%), the United Kingdom (19%), and China (17%) were the leading sources of imported gallium.

In addition to gallium metal, GaAs wafers were imported into the United States (table 6). In 2009, 28,300 kilograms (kg) of undoped GaAs wafers and 117,000 kg of doped GaAs wafers were imported. Imports of undoped GaAs wafers were significantly more than those in 2008, while imports of doped GaAs wafers were 29% less than those in 2008. The large volumes of undoped GaAs wafers were primarily imported from Canada and the United Kingdom. The large increase was most likely owing to intercompany transfers between foreign and the U.S. subsidiary of the same company. The data listed in table 6 may include some packaging material and, as a result, quantities may be higher than the actual total weight of imported wafers.

World Review

Imports of gallium into Japan and the United States, the two leading consuming countries, were used as the basis for estimating world gallium production. Estimated crude gallium production was 79 t in 2009. Principal world producers were China, Germany, Kazakhstan, Russia, and Ukraine. Gallium also was recovered in Hungary, Japan, and Slovakia. Refined gallium production was estimated to be about 122 t; this included some new scrap refining. China, Japan, the United Kingdom, and the United States refined gallium. Gallium was recycled from new scrap in Canada, Germany, Japan, the United Kingdom, and the United States.

China.—In August, MCP Group SA (Tilly, Belgium) announced that it had formed a joint venture with Chinese company Golden Harvest Ltd. to create an integrated gallium operation capable of producing both low-purity and high-purity gallium. The joint venture, named MCP Crystal, consisted of four operations—three 99.99% (4N) plants and one 6N and 7N plant. The 4N plants were expected to collectively produce between 70 t/yr and 80 t/yr of gallium. The plants were located in Henan, Shangxi, and Sichuan Provinces (Metal Bulletin, 2009).

In 2009, Aluminum Corp. of China Ltd. (Chalco) continued idling additional alumina refineries since the reduction of output first began in the last quarter of 2008 because of the deteriorating global economy and declining price of aluminum. By March, Chalco had cut alumina production by 4.1 million metric tons, equivalent to 38% of its alumina refining capacity. As the largest producer of byproduct gallium in China, Chalco's reduction in alumina production was expected to affect the worldwide supply of gallium (Ye, 2009).

Malaysia.—In December, Osram Opto Semiconductors (Munich, Germany) announced the completion of its second LED chip production plant, in Penang, Malaysia. The new facility augmented the company's main production facility in Regensburg, Germany. The new facility produced indium gallium nitride (InGaN)-based LED chips, fabricated on 4-inch wafers, which form the basis for the blue, green, and white LEDs used primarily in architecture, general lighting, and display backlighting in mobile terminal devices (LEDs Magazine, 2009c).

Taiwan.—In an effort to meet the growing demand for GaAs-based amplifiers, Kopin Corp. (Taunton, MA) announced in August that it had invested $6.3 million in its majority-owned Asian foundry venture, Kopin Taiwan Corp. to transition from 4-inch to 6-inch GaAs epiwafer production (Semiconductor Today, 2009e).

To meet the increasing demand for GaAs wafers, WIN Semiconductors Corp. of Taiwan opened the second of its

6-inch GaAs wafer fabrication plants. The new plant's capacity of 5,000 wafers per month (wpm) augments WIN's existing capacity of 7,000 wpm (Semiconductor Today, 2009h).

In December, Visual Photonics Epitaxy Co. of Taiwan announced plans to expand its GaAs wafer production capacity by 40% to 60% in 2010 by increasing the number of its metal-organic chemical vapor deposition (MOCVD) reactors to 30 from its current 22. The total expansion investment was expected to cost $18 million (Semiconductor Today, 2009c).

SemiLEDs Corp. opened a third high-power LED chip facility in Hsinchu Science Park, Taiwan. The new production facility increased SemiLEDs high-power LED chip production capacity to 15 million chips per month. LG Corp. (Seoul, Republic of Korea) planned to establish a new LCD glass panel and LED backlight production facility in Paju, Gyeonggi Province, Republic of Korea. The plant eventually would increase the company's LED production to four times its current capacity (LEDs Magazine, 2009a, d).

Outlook

According to IQE, "smartphones" represented a fundamental structural shift in mobile communications. Growth of smartphones, which on the average contain 480% more GaAs-rich RF content than standard cellular telephones, were expected to account for 19% of all handset sales in 2010, increasing to more than 50% by 2014. Installation of 3G and 4G mobile networks in India and the Republic of Korea were expected to aid the sales growth of smartphones further. Growth in GaAs demand will also be driven by new applications for wireless fidelity (WiFi) such as point-to-point communications, smart meters, and tablet personal computer technologies. Strategy Analytics predicted that the GaAs industry would grow at a compound annual growth rate of 5%, increasing to $4.7 billion by 2014, up from $3.7 billion in 2009 (Business Wire, 2010; IQE, plc, 2010).

Research and consulting firm iSuppli Corp. predicted the GaN power management market would reach $184 million in revenue by 2013, up from virtually zero in 2009. The firm indicated that two events—silicon reaching its practical limits in power management semiconductors and breakthroughs in growing GaN layers on silicon—favored GaN power management devices taking market share away from conventional metal oxide semiconductor field-effect transistors, driver ICs, and voltage regulator ICs. The GaN power management devices' improved efficiency and smaller size would be in high demand for portable electronic products as well as for power-hungry enterprise servers and wired communications infrastructure equipment (Shaw, 2010).

Strategy Analytics indicated that the U.S. defense industry would continue to be the driver for the RF and power management GaN microelectronics market. The firm expected military applications to represent nearly one-half of the estimated $380 million market by 2014 (Semiconductor Today, 2010a).

According to Strategies Unlimited, the HB LED market was expected to experience unprecedented growth opportunities during the next 5 years from general lighting applications and backlights for LCDs in computer monitors, notebook computers, and televisions. The firm forecast that the HB LED market would increase to $8.2 billion in 2010, a 52% increase from $5.4 billion in 2009, and projected the market to increase to $20.5 billion in 2014, growing at an average rate of 30.6% per year. The firm predicted LED unit volume growth of 44% in 2010, and forecast that by 2014 LED unit volume would be four times higher than that in 2009, exceeding 200 billion units. To meet the projected LED demand, Strategies Unlimited calculated that 200 additional MOCVD reactors would be needed by 2010 and another 280 reactors would be needed by 2011 (Steele, 2010).

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TABLE 1

SALIENT U.S. GALLIUM STATISTICS[1]

(Kilograms unless otherwise specified)

		2005	2006	2007	2008	2009
Production		--	--	--	--	--
Imports for consumption		15,800	26,900	37,100	41,100	35,900
Consumption		18,700	20,300	25,100	28,700	24,900
Price[2]	dollars per kilogram	538	443	530	579	449

-- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Estimate based on average value of U.S. imports of high-purity gallium.

TABLE 2

U.S. CONSUMPTION OF GALLIUM, BY END USE[1, 2]

(Kilograms)

End use	2008	2009
Optoelectronic devices:		
Laser diodes and light-emitting diodes	3,800	5,370
Photodetectors and solar cells	5,040	849
Integrated circuits:		
Analog	16,900	17,200
Digital	2,310	1,280
Research and development	497	135
Other	110	68
Total	28,700	24,900

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes gallium metal and gallium compounds.

TABLE 3

STOCKS, RECEIPTS, AND CONSUMPTION OF GALLIUM, BY GRADE[1, 2]

(Kilograms)

Purity	Beginning stocks	Receipts	Consumption	Ending stocks
2008:				
99.99% to 99.999%	3,530	155	976	2,710
99.9999%	2,420	6,060	7,550	929
99.99999% to 99.999999%	51	622	500	173
Total	6,010	6,830	9,030	3,820
2009:				
99.99% to 99.999%	2,710	528	--	3,240
99.9999%	929	927	1,120	740
99.99999% to 99.999999%	173	383	438	118
Total	3,820	1,840	1,550	4,100

-- Zero.

[1] Consumers only.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 4
ESTIMATED AVERAGE GALLIUM PRICES

(Dollars per kilogram)

Gallium metal	2008	2009
Purity ≥ 99.9999%; average value of U.S. imports	579	449
Purity ≤ 99.99%; average value of U.S. imports	361	304

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF GALLIUM (UNWROUGHT, WASTE, AND SCRAP), BY COUNTRY[1]

	2008		2009	
Country	Quantity (kilograms)	Value[2]	Quantity (kilograms)	Value[2]
Armenia	888	$396,000	--	--
Canada	10,200	6,130,000	10,500	$3,670,000
China	6,600	2,930,000	6,100	2,240,000
France	98	107,000	719	325,000
Germany	13,500	5,080,000	7,110	2,630,000
Hungary	1,410	639,000	--	--
Japan	616	548,000	915	504,000
Singapore	516	204,000	--	--
Ukraine	1,170	445,000	3,750	990,000
United Kingdom	5,930	1,950,000	6,740	2,170,000
Other	145 [r]	29,400 [r]	106	38,700
Total	41,100	18,500,000	35,900	12,600,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

Source: U.S. Census Bureau.

TABLE 6

U.S. IMPORTS FOR CONSUMPTION OF GALLIUM ARSENIDE WAFERS, BY COUNTRY[1]

	2008		2009	
Material and country	Quantity (kilograms)	Value[2]	Quantity (kilograms)	Value[2]
Undoped:				
Austria	94	$37,600	30	$16,000
Canada	--	--	15,800	2,480,000
France	250	48,800	--	--
Japan	112	12,600	72	3,600
Singapore	150	25,000	--	--
Taiwan	324	101,000	886	173,000
United Kingdom	18	3,800	11,500	21,900
Other	7 r	11,700 r	13	24,200
Total	955	241,000	28,300	2,720,000
Doped:				
China	20,800	19,500,000	5,680	10,200,000
Finland	12,600	6,030,000	1,370	1,410,000
France	2,810	6,480,000	1,630	4,290,000
Germany	34,100	33,500,000	29,500	18,200,000
Italy	2,330	352,000	6,120	196,000
Japan	60,900	54,000,000	52,800	57,000,000
Korea, Republic of	13,600	2,400,000	2,610	946,000
Malaysia	3,720	853,000	82	43,300
Singapore	2,180	5,180,000	6,430	10,100,000
Taiwan	7,860	22,000,000	7,560	22,000,000
United Kingdom	1,290	1,190,000	1,160	2,280,000
Other	2,580 r	3,690,000 r	2,050	1,790,000
Total	165,000	155,000,000	117,000	129,000,000

rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

Source: U.S. Census Bureau.

TABLE 7

ESTIMATED WORLD ANNUAL PRIMARY GALLIUM PRODUCTION CAPACITY, DECEMBER 31, 2009[1]

(Metric tons)

Country	Capacity
China	59
Germany	35
Hungary	8
Japan	20
Kazakhstan	25
Russia	19
Slovakia	8
Ukraine	10
Total	184

[1] Includes capacity at operating plants as well as at plants on standby basis.

GARNET, INDUSTRIAL

By Donald W. Olson

Domestic survey data and table were prepared by Connie Lopez, statistical assistant.

In 2009, U.S. production of crude garnet concentrate for industrial use was estimated to be 45,600 metric tons (t) valued at about $6.85 million (table 1). U.S. imports and exports of industrial garnet were estimated to be 37,900 t and 13,200 t, respectively. U.S. apparent consumption was estimated to be 70,300 t.

This report includes information on garnet produced in the United States that was used for industrial purposes. Current information on gem-grade garnet can be found in the U.S. Geological Survey (USGS) Minerals Yearbook, volume I, Metals and Minerals, chapter on gemstones. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using unrounded data.

The name "garnet" comes from either the Middle English word "gernet," meaning dark red, or the Latin word "granatus," meaning grain, possibly a reference to the pomegranate (*Punica granatum*), a fruit plant with red seeds similar in shape, size, and color to some garnet crystals. Garnet has been used as a gemstone for centuries. Garnet necklaces have been found in burial sites as far back as the Bronze Age, and garnet is found among the ornaments adorning the oldest Egyptian mummies. Garnet also is ideal for many industrial applications because of its angular fractures, relatively high hardness and specific gravity, chemical inertness, nontoxicity, lack of crystalline silica, and its ability to be recycled.

Garnet is the general name given to a group of complex silicate minerals, all with isometric crystal structure and similar properties and chemical composition. The general chemical formula for the garnet minerals is $A_3B_2(SiO_4)_3$, where A can be calcium, ferrous iron, magnesium, or manganese, and B can be aluminum, chromium, ferric iron, or rarely, titanium. The most common garnet minerals are classified into three groups—the aluminum-garnet group, the chromium-garnet group, and the iron-garnet group. The most common minerals of the aluminum-garnet group are almandine or almandite, grossularite, pyrope, and spessartite. Andradite is the most common iron-garnet mineral, and uvarovite is the most common chromium garnet. Garnet occurs worldwide in many rock types, principally gneisses and schists; other sources include contact metamorphic rocks, metamorphosed crystalline limestones, pegmatites, and serpentinites. Alluvial garnet is associated with heavy-mineral sand and gravel deposits in many parts of the world. Occurrences of garnet are numerous; however, relatively few commercially viable garnet deposits have been discovered.

Production

The U.S. industrial garnet industry is dominated by a few major producers. The garnet industry has encountered progressively higher production costs and tighter profit margins since the mid-1990s. These factors have resulted in the loss of noncompetitive producers. Because of the need to keep production costs at a minimum, the most competitive producers are those who produce garnet in combination with one or two other minerals, have reserves that can be mined at a low cost, and have the ability to react rapidly to changes in market demand. The value of industrial garnet is influenced by the size and grade of reserves, the type and quality of garnet mined, the proximity of deposits to infrastructure and consumers, and the milling costs. Pricing within the U.S. garnet industry is very competitive, and suppliers must provide a high level of customer service. The majority of industrial-grade garnet mined in the United States is almandine (iron aluminum silicate) and pyrope (magnesium aluminum silicate); some andradite (calcium iron silicate) also is mined domestically. Industrial garnet is produced from alluvial bar and beach deposits, like those in Idaho and Montana (also those in Australia and India), and it is produced from hard rock deposits, like those in New York (Moore, 2006).

Four U.S. companies accounted for all domestic production—one in Idaho, one in Montana, and two in New York. The USGS obtained the data in this report through a survey of U.S. industrial garnet producers. Two of the four domestic producers reported their output and sales to the USGS, and production amounts and values for the nonreporting companies were estimated.

In 2009, U.S. production of crude garnet concentrate for industrial use was estimated to be 45,600 t valued at about $6.85 million (table 1). This was a 28% decrease in production and a decrease of 49% in value compared with 62,900 t valued at $13.6 million in 2008. The United States accounted for about 3% of global industrial garnet production. Refined garnet material sold or used during 2009 was 22,100 t valued at $6.10 million, a unit value of $276 per ton, which was a 56% decrease in quantity, a decrease of about 55% in value, and a slight increase in unit value compared with the 2008 levels. Garnet producers in 2009 were Barton Mines Co., LLC in Warren County, NY; Emerald Creek Garnet Co. in Benewah County, ID; NYCO Minerals, Inc. in Essex County, NY; and Ruby Valley Garnet LLC in Madison County, MT. In addition to the producers cited above, International Garnet Abrasive Inc. in Clinton County, NY, processed and sold all the garnet mined by NYCO Minerals in 2009.

Consumption

In 2009, the estimated U.S. apparent consumption of industrial garnet was 70,300 t. The United States accounted for about 5% of global industrial garnet use.

The end uses for garnet in the United States and their estimated market share in 2009 were waterjet cutting, 35%; abrasive blasting media, 30%; water filtration, 15%; abrasive powders, 10%; and other, 10%. Domestic industries that consume garnet include aircraft and motor vehicle manufacturers, ceramics and glass producers, electronic component manufacturers, filtration plants, glass polishing, the petroleum industry, shipbuilders, textile stonewashing, and wood-furniture-finishing operations.

Most industrial garnet is used as an abrasive because of its hardness, which ranges from 6 to 7.5 on the Mohs scale. High-quality, high-value garnet grain has been used principally for such applications as optical lens grinding and plate-glass grinding for more than a century; industrial diamond and fused aluminum oxide are competitors in these applications. In recent years, industrial garnet powders have been used for high-quality, scratch-free lapping of semiconductor materials and other metals. Garnet has replaced some silica sand in the blast cleaning market because garnet does not have the health risks associated with the inhalation of airborne crystalline silica dust. At present, however, silica sand and mineral slag continue to be the most widely used media in blasting. The U.S. petroleum industry is one of the leading garnet-consuming industries, using garnet for cleaning drill pipes and well casings. The aluminum aircraft manufacturing and shipbuilding industries use garnet for blast cleaning and for finishing metal surfaces. Similar uses include the cleaning and conditioning of aluminum and other soft metals as well as metal cleaning by structural steel fabrication shops. Garnet entrained in high-pressure streams of water also is used to cut many different materials. Garnet powders generally are used for antiskid surfaces, antislip paints, and glass and ceramic polishes.

Low-quality industrial garnet, which has lower hardness and is more highly fractured, is used as a filtration medium in water purification systems because of its relative inertness and resistance to chemical degradation. Garnet is well suited for water filtration and treatment because it is relatively heavy and chemically stable. Mixed-media water filtration, which uses a mixture of anthracite, garnet, and silica sand, has displaced older filtration methods because it provides better water quality. Garnet competes with ilmenite, magnetite, plastics, and silica sand as a filtration medium.

Other applications include the manufacture of coated abrasives and the finishing of felt, hard rubber, leather, plastics, and wood. In the coated-abrasive market, garnet falls between low-cost quartz sand or staurolite and more costly manufactured abrasives, such as fused alumina and silicon carbide. Garnet is more efficient than quartz sand in most coated-abrasive applications. Owing to its friable nature and lower hardness, garnet cannot compete with manufactured abrasives in metalworking applications that require substantial metal removal.

Prices

Industrial garnet is priced at a wide range, depending on application, quality, quantity purchased, source, and type. During 2009, domestic values for crude concentrates for different applications ranged from about $83 to $226 per metric ton, with an average for the year of $150 per ton. Domestic values for refined garnet for different applications sold during the year ranged from $83 to $331 per ton, with an average for the year of $276 per ton.

The estimated average values of garnet from other leading producers around the world based on the value of import shipments are as follows: Australia, $197 per ton; Canada, $312 per ton; China, $361 per ton; and India, $209 per ton.

Foreign Trade

Lower priced foreign imports slowly began displacing U.S. production in domestic markets during the 1990s. For the past 5 years, industrial garnet imports have provided between 44% and 60% of the U.S. total industrial garnet supply.

The U.S. Census Bureau compiles trade data on exports and imports of industrial garnet mixed with other natural abrasive commodities, such as emery and corundum, so the data cannot be identified specifically as garnet. Based on reports from some producers and other industry sources, exports and imports of industrial garnet were estimated to be 13,200 t and 37,900 t, respectively, in 2009. Exports increased by about 6% from those of 2008, and imports decreased by about 23% compared with those of 2008. In 2009, Australia, Canada, China, and India continued to supply the majority of the U.S. garnet imports, with Australia providing 45%; India, 39%; China, 10%; Canada, 3%; and other countries, 3% of industrial garnet imported into the United States for consumption. Garnet exported by the United States was shipped to Asian, Canadian, Caribbean, Central American, European, and South American markets. About 63% of garnet exports from the United States went to Canada and Mexico.

World Review

The USGS estimated total world industrial garnet production to be about 1.39 million metric tons. In 2009, India, China, Australia, and the United States, in decreasing tonnage order, were the leading producers. In 2009, India produced about 50% of total global production; China, about 32%; Australia, 12%; the United States, about 3%; and other countries, about 3%. Russia and Turkey have been mining garnet in recent years, primarily for domestic markets. Small garnet-mining operations also are located in Canada, Chile, the Czech Republic, Pakistan, South Africa, Spain, Thailand, and Ukraine. Production in most of these countries is for domestic use.

Australian industrial garnet production and exports have been increasing since 1998 and are expected to continue increasing. China and India also have increased garnet output in the past decade and have become significant garnet sources for other countries. Worldwide end uses and their estimated market shares are abrasive blasting media, 60%; waterjet cutting, 20%; water filtration, 10%; and other end uses, 10% (Rapple, 2006).

Outlook

The U.S. garnet industry has encountered higher production costs and tighter profit margins during recent years. The industry has also been competing with lower-priced foreign imports that have displaced U.S. production in domestic markets, so much so that for 2 of the past 5 years, industrial garnet imports have exceeded domestic industrial garnet production. This has resulted in the closure of noncompetitive operations. Because of the need to keep production costs at a minimum, the most competitive producers are those who produce garnet in combination with one or two other minerals, have reserves that can be mined at a low cost, and have the ability to react rapidly to changes in market demand. An example of this type of mining operation is the mine being developed in Coos County, OR, by Oregon Resources Corp. The mine was expected to begin production during mid-March 2011 and be in full operation by fall 2011. Oregon Resources estimated that the mine will produce 635,000 tons per year of ore, yielding 54,400 t of chromite and 16,300 to 18,100 t of spessartite garnet each year. The garnet is intended for waterjet cutting markets. Zircon will also be produced. Oregon Resources projected a 15-year mine life for the operation (James Dingman, director of marketing and sales, Oregon Resources Corp., written commun., February 28, 2007; oral commun., December 17, 2010).

Worldwide demand for industrial garnet is expected to continue, especially within the markets for abrasive grains for waterjet cutting and for abrasive blasting media. Garnet demand also is expected to continue for aircraft manufacturing and shipbuilding where significant amounts of garnet are used for blast cleaning and finishing of metal surfaces and for waterjet cutting.

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TABLE 1

SALIENT U.S. INDUSTRIAL GARNET STATISTICS[1]

		2005	2006	2007	2008	2009
United States:						
Crude production:						
Quantity	metric tons	40,100	34,100	61,400	62,900	45,600
Value	thousands	$3,840	$4,240	$11,300	$13,600	$6,850
Sold or used:[2]						
Quantity	metric tons	23,100	16,800	20,700	49,800	22,100
Value	thousands	$6,200	$5,330	$5,830	$13,500	$6,100
Exports:						
Quantity	metric tons	13,400	13,300	12,000	12,500	13,200
Value	thousands	$9,700	$9,450	$9,620	$9,050	$10,700
Imports for consumption:						
Quantity	metric tons	41,800	50,800	52,300	49,200	37,900
Value	thousands	$5,910	$8,340	$8,010	$11,500	$8,890
Apparent consumption[3]	metric tons	68,600	71,600	102,000	99,700	70,300
World, production[e]	do.	1,190,000	1,370,000	1,380,000	1,310,000	1,390,000

[e] Estimated. do. Ditto.

[1] Data are rounded to no more than three significant digits.

[2] May exclude some unreported exports.

[3] Domestic production plus imports minus exports.

GEMSTONES

By Donald W. Olson

Domestic survey data and tables were prepared by Connie Lopez, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2009, the estimated value of natural gemstones produced in the United States was more than $8.41 million, and the estimated value of U.S. laboratory-created gemstone production was more than $27.2 million. The total estimated value of U.S. gemstone production was about $35.6 million. The value of U.S. gemstone imports was $13.3 billion, and the value of combined U.S. gemstone exports and reexports was estimated to be $10.5 billion.

In this report, the terms "gem" and "gemstone" mean any mineral or organic material (such as amber, pearl, petrified wood, and shell) used for personal adornment, display, or object of art because it possesses beauty, durability, and rarity. Of more than 4,000 mineral species, only about 100 possess all these attributes and are considered to be gemstones. Silicates other than quartz are the largest group of gemstones in terms of chemical composition; oxides and quartz are the second largest (table 1). Gemstones are subdivided into diamond and colored gemstones, which in this report designates all natural nondiamond gems. In addition, laboratory-created gemstones, cultured pearls, and gemstone simulants are discussed but are treated separately from natural gemstones (table 2). Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using unrounded data. Current information on industrial-grade diamond and industrial-grade garnet can be found in the U.S. Geological Survey (USGS) Minerals Yearbook, volume I, Metals and Minerals, chapters on industrial diamond and industrial garnet, respectively.

Gemstones have fascinated humans since prehistoric times. They have been valued as treasured objects throughout history by all societies in all parts of the world. Amber, amethyst, coral, diamond, emerald, garnet, jade, jasper, lapis lazuli, pearl, rock crystal, ruby, serpentine, and turquoise are some of the first stones known to have been used for making jewelry. These stones served as symbols of wealth and power. Today, gems are worn more for pleasure or in appreciation of their beauty than to demonstrate wealth. In addition to jewelry, gemstones are used for collections, decorative art objects, and exhibits.

Legislation and Government Programs

No industrial diamond remained in the National Defense Stockpile (NDS), which is managed by the Defense National Stockpile Center (DNSC), Defense Logistics Agency. The last stocks of industrial diamond stones were completely sold during 2008 (Lough, 2008). At yearend 2009, DNSC had no plans to stockpile any inventory of industrial diamond in the NDS.

Production

U.S. gemstone production data were based on a survey of more than 230 domestic gemstone producers conducted by the USGS. The survey provided a foundation for projecting the scope and level of domestic gemstone production during the year. However, the USGS survey did not represent all gemstone activity in the United States, which includes thousands of professional and amateur collectors. Consequently, the USGS supplemented its survey with estimates of domestic gemstone production from related published data, contacts with gemstone dealers and collectors, and information gathered at gem and mineral shows.

Commercial mining of gemstones has never been extensive in the United States. More than 60 varieties of gemstones have been produced commercially from domestic mines, but most of the deposits are relatively small compared with those of other mining operations. In the United States, much of the current gemstone mining is conducted by individual collectors, gem clubs, and hobbyists rather than by businesses.

The commercial gemstone industry in the United States consists of individuals and companies that mine gemstones or harvest shell and pearl, firms that manufacture laboratory-created gemstones, and individuals and companies that cut and polish natural and laboratory-created gemstones. The domestic gemstone industry is focused on the production of colored gemstones and on the cutting and polishing of large diamond stones. Industry employment is estimated to be between 1,000 and 1,200.

Most natural gemstone producers in the United States are small businesses that are widely dispersed and operate independently. The small producers probably have an average of less than three employees, including those who only work part time. The number of gemstone mines operating from year to year fluctuates because the uncertainty associated with the discovery and marketing of gem-quality minerals makes it difficult to obtain financing for developing and sustaining economically viable operations.

The total value of natural gemstones produced in the United States during 2009 was estimated to be about $8.41 million (table 3). This production value was a 27% decrease from that of 2008, owing to a 69% decrease in shell production.

Natural gemstone materials indigenous to the United States are collected, produced, and (or) marketed in every State. During 2009, all 50 States produced at least $1,330 worth of gemstone materials. There were 10 States that accounted for 79% of the total value, as reported by survey respondents. These States were, in descending order of production value, Arizona, Oregon, Utah, California, Idaho, Colorado, Arkansas, Montana, North Carolina, and Tennessee. Some States were known for the production of a single gemstone material—Tennessee for freshwater pearls, for example. Other States produced a variety of gemstones; for example, Arizona's gemstone deposits included agate, amethyst, azurite, chrysocolla, garnet, jade, jasper, malachite, obsidian, onyx, opal, peridot, petrified wood, smithsonite, and turquoise. There was also a wide variety of gemstones found and produced in California, Idaho, Montana, and North Carolina.

In August 2009, a 310-carat emerald crystal was found at Adams Emerald Mine, Hiddenite District, North Carolina. A 64.83-carat gem, named the Carolina Emperor, was cut from the crystal. The Carolina Emperor is North America's largest faceted emerald, and its value was estimated to be more than $1.5 million. Of all emeralds found in North America, the 20 largest were found in North Carolina, and the emeralds that have been found in North Carolina are the most valuable that have been found in North America (McClatchy-Tribune News Service, 2010; Speer, 2011).

In 2009, the United States had only one active operation in a known diamond-bearing area in Crater of Diamonds State Park near Murfreesboro in Pike County, AR. The State of Arkansas maintains a dig-for-fee operation for tourists and rockhounds at the park; Crater of Diamonds is the only diamond mine in the world that is open to the public. The diamonds occur in a lamproite breccia tuff associated with a volcanic pipe and in the soil developed from the lamproite breccia tuff. In 2009, 918 diamond stones with an average weight of 0.199 carats were recovered at the Crater of Diamonds State Park. Of the 918 diamond stones recovered, 29 weighed more than 1 carat. Since the diamond-bearing pipe and the adjoining area became a State park in 1972, 28,745 diamond stones with a total carat weight of 5,700.22 have been recovered (Waymon Cox, park interpreter, Crater of Diamonds State Park, written commun., July 19, 2010). Exploration has demonstrated that there is about 78.5 million metric tons (Mt) of diamond-bearing rock in this diamond deposit (Howard, 1999, p. 62). An Arkansas law enacted early in 1999 prohibits commercial diamond mining in the park (Diamond Registry Bulletin, 1999).

No diamond mines have operated commercially in the United States since 2002. Diamond was produced at the Kelsey Lake diamond mine, located close to the Colorado-Wyoming State line near Fort Collins, CO, for several years until April 2002. The Kelsey Lake property has been fully reclaimed.

There has been some interest in exploration for diamond deposits in areas of the United States with geologic settings and terrain that are similar to Canadian diamond mining areas. These areas are in Alaska, Colorado, Minnesota, Montana, and Wyoming (Associated Press, 2002, 2004; Diamond Registry Bulletin, 2005). Even though some exploration has taken place in these States, they remain largely underexplored for diamonds (Iron Range Resources & Rehabilitation Board, 2010). Although exploration and field studies have found many diamond indicators and a number of large diamond deposits, none have attracted long-term investors or been opened as commercially feasible mines thus far.

In addition to natural gemstones, laboratory-created gemstones and gemstone simulants were produced in the United States in 2009. Laboratory-created or synthetic gemstones have the same chemical, optical, and physical properties as the natural gemstones. Simulants have an appearance similar to that of a natural gemstone material, but they have different chemical, optical, and physical properties. Laboratory-created gemstones that have been produced in the United States include alexandrite, diamond, emerald, garnet, moissanite, ruby, sapphire, spinel, turquoise, and zirconia. However, during 2009, only cubic zirconia, diamond, moissanite, and turquoise were produced commercially. Simulants of coral, lapis lazuli, malachite, and turquoise also are manufactured in the United States. In addition, certain colors of laboratory-created sapphire and spinel, used to represent other gemstones, are classified as simulants.

Laboratory-created gemstone production in the United States was valued at more than $27.2 million during 2009, which was a 47% decrease compared with that of 2008. This was owing to a very large decrease in laboratory-created moissanite production. The value of U.S. simulant gemstone output was estimated to be more than $100 million. Five companies in five States, representing virtually the entire U.S. laboratory-created gemstone industry, reported production to the USGS. The States with reported laboratory-created gemstone production were, in descending order of production value, Florida, New York, Massachusetts, North Carolina, and Arizona.

Since the 1950s, when scientists manufactured the first laboratory-created bits of diamond grit using a high-pressure, high-temperature (HPHT) method, this method of growing diamonds has become relatively commonplace in the world as a technology for laboratory-created diamonds, so much so that thousands of small plants throughout China were using the HPHT method and producing laboratory-created diamonds suitable for cutting as gemstones. Gem-quality diamonds of one carat or more are harder to manufacture because at that size it is difficult to consistently produce diamonds of high quality, even in the controlled environment of a lab using the HPHT method. After more than 50 years of development, that situation has changed, and several laboratory-created diamond companies were producing high-quality diamonds that equal those produced from mines (Park, 2007).

Gemesis Corp., Sarasota, FL, consistently produced gem-quality laboratory-created diamond and reported a 10th year of production in 2009. The laboratory-created diamonds are produced using equipment, expertise, and technology developed by a team of scientists from Russia and the University of Florida. The weight of the laboratory-created diamond stones ranges from 1½ to 2 carats, and most of the stones are yellow, brownish yellow, colorless, and green. Gemesis uses diamond-growing machines, each machine capable of growing 3-carat rough diamonds by generating HPHT conditions that recreate the conditions in the Earth's mantle where natural diamonds form (Davis, 2003). Gemesis could be producing as many as 30,000 to 40,000 stones each year, and annual revenues may reach $70 million to $80 million. Gemesis diamonds are available for retail purchase in jewelry stores and on the Internet, and the prices of the Gemesis laboratory-created diamonds are 30% to 50% less than those of comparable natural diamond but above the prices of simulated diamond (Gemesis Corp., 2010).

In the early 2000s, Apollo Diamond, Inc., near Boston, MA, developed and patented a method for growing single, extremely pure, gem-quality diamond crystals by chemical vapor deposition (CVD). The CVD technique transforms carbon into plasma, which is then precipitated onto a substrate as diamond. CVD had been used for more than a decade to cover large surfaces with microscopic diamond crystals, but in developing this process Apollo discovered the temperature, gas composition, and pressure combination that resulted in the growth of a single diamond crystal. These CVD diamonds may not be distinguishable from natural diamond by some tests (Davis, 2003). In 2007, Apollo Diamond produced laboratory-created stones that ranged from 1 to 2 carats and expected to expand to larger stones in the future. Growth of CVD diamonds is limited only by the size of the seed placed in the diamond growing chamber. In 2008, the company increased its production of large stones. Apollo diamonds sell at prices that average 15% less than those of comparable natural diamonds (Apollo Diamond, Inc., 2008). Both Apollo and Gemesis prefer to call their diamonds "cultured" rather than laboratory-created, referring to the fact that the diamonds are grown much like a cultured pearl is grown. In addition to their use as gemstones, CVD diamond could be used to make extremely powerful lasers; to create frictionless medical replacement joints; to create windows on spacecraft; to create surgical diamond blades and scalpels; or as coatings for car parts that would not scratch or wear out. The greatest potential use for CVD diamond is as a material for high-tech uses in computers and other electronic devices that utilize processors (Maney, 2005; Park, 2007).

In the mid-2000s, the Carnegie Institution of Washington Geophysical Laboratory and the University of Alabama jointly developed and patented a faster CVD process and apparatus to produce ½-inch thick 10-carat single diamond crystals using microwave plasma technology. This method has up to 100 times faster growth rates (averaging 100 micrometers per hour) than previous CVD methods and allows multiple crystals to be grown simultaneously. This crystal size is about five times that of commercially available laboratory-created diamonds produced by HPHT methods and other CVD techniques (Willis, 2004; Carnegie Institution of Washington, 2005; Science Blog, 2005). Apollo and the Carnegie Institution have noted that diamonds produced by the CVD method are harder than natural diamonds and diamonds produced by HPHT methods.

Research at the Carnegie Institution continued improving the microwave plasma CVD method, developing a process to anneal the diamonds at temperatures up to 2000 °C using a microwave plasma below atmospheric pressure. In this process, the diamond crystals, which are originally yellow-brown if produced at very high growth rates, are turned colorless or light pink. This low-pressure/high-temperature annealing process enhances the optical properties of this rapid-grown CVD single crystal diamond, and the size of the crystals that can be treated is not limited. This process is thought to produce better synthetic diamonds for high pressure devices and window materials with improved optical properties in the ultraviolet to infrared range. These high-quality, single-crystal diamonds likely will have a variety of applications in addition to their use as gems, such as using the diamond crystals as anvils in high-pressure research or optical uses that take advantage of the outstanding transparency of diamond. Another application might be in quantum computing, by utilizing vacancy centers in the diamond's crystal lattice for storing quantum information (Carnegie Institution for Science, 2008).

In 2009, Charles & Colvard, Ltd. in North Carolina entered its 12th year as the world's only manufacturer of moissanite, a gem-quality laboratory-created silicon carbide. Moissanite is also an excellent diamond simulant, but it is being marketed for its own gem qualities. Moissanite exhibits a higher refractive index (brilliance) and higher luster than diamond. Its hardness is between those of corundum (ruby and sapphire) and diamond, which gives it durability (Charles & Colvard, Ltd., 2010b). Charles & Colvard reported that production and sales were down in 2009 compared with those of the previous year as a result of the effects of the economic recession. However, this trend did begin to reverse in the fourth quarter and net sales increased 10% compared with net sales in the third quarter of 2009 (Charles & Colvard, Ltd., 2010a).

U.S. shell production decreased by 69% in 2009 compared with that of 2008. U.S. mussel shells are used as a source of mother-of-pearl and as seed material for culturing pearls. Pearl producers in Japan have begun using manmade seed materials or seed materials from China and other sources in addition to stockpiled material. In addition, the popularity of darker and colored pearls and freshwater pearls that do not use U.S. seed material has increased. In some regions of the United States, shell from mussels was being used more as a gemstone based on its own merit rather than as seed material for pearls. This shell material was being processed into mother-of-pearl and used in beads, jewelry, and watch faces.

Consumption

Historically, diamond gemstones have proven to hold their value despite wars or economic depressions (Schumann, 1998, p. 8), but this did not hold true during the recent worldwide economic recession. Diamond and colored gemstones value and sales decreased during the economic downturn in 2008 and continued into 2009. Gemstone production, trade, and consumption demonstrated significant decreases during 2008, mostly concentrated in the last 4 months of the year, and continued through most of 2009. U.S. gemstone consumption and sales increased in December 2009.

Although the United States accounted for little of the total global gemstone production, it was the world's leading diamond and nondiamond gemstone market. It was estimated that U.S. gemstone markets accounted for more than 35% of world gemstone demand in 2009. The U.S. market for unset gem-quality diamond during the year was estimated to be about $12.7 billion, a decrease of 35% compared with that of 2008. Domestic markets for natural, unset nondiamond gemstones totaled approximately $779 million in 2009, which was a 30% decrease from that of 2008. These large declines in domestic markets were a reflection of the impact of the global recession on luxury spending.

In the United States, about two-thirds of domestic consumers designate diamond as their favorite gemstone when surveyed (Wade, 2006). The popularity of diamonds with domestic consumers is also evidenced by the U.S. diamond market making up 94% of the total U.S. gemstone market. Colored natural gemstones, colored laboratory-created gemstones, and "fancy" colored diamonds remained popular in 2009, but the values of the domestic markets for almost all types of colored natural, unset nondiamond gemstones decreased from the 2008 values (table 10), also owing to the impact of the recession on luxury spending. The largest demand for colored stones was in the American and Asian colored diamond markets with strong sales of champagne, cognac, grey, black, pink, orange, and yellow stones (Diamond Registry Bulletin, 2007). This trend was first evident in 2007 and has remained through the present.

There were about 200,000 diamond jewelry retail outlets worldwide in 2009. From these retail outlets, about 45% of diamond jewelry was sold in the United States, 33% in Asia, and 11% in Europe. An estimated 32,000 retail outlets specialize in fine jewelry in the United States. The estimated U.S. retail jewelry sales were $59 billion in 2009, down slightly from sales of $60 billion in 2008 (National Jeweler, 2010c). U.S. jewelry sales showed an increase of 5.6% more than that of the previous year during the 2009 holiday shopping season (National Jeweler, 2009).

Prices

Gemstone prices are governed by many factors and qualitative characteristics, including beauty, clarity, defects, demand, durability, and rarity. Diamond pricing, in particular, is complex; values can vary significantly depending on time, place, and the subjective valuations of buyers and sellers. There are more than 14,000 categories used to assess rough diamond and more than 100,000 different combinations of carat, clarity, color, and cut values used to assess polished diamond.

Colored gemstone prices are generally influenced by market supply and demand considerations, and diamond prices are supported by producer controls on the quantity and quality of supply. Values and prices of gemstones produced and (or) sold in the United States are listed in tables 3 through 5. In addition, customs values for diamonds and other gemstones imported, exported, or reexported are listed in tables 6 through 10.

De Beers Group companies remain a significant force, influencing the price of about 40% of gem-quality diamond sales worldwide during 2009 because the companies mine a significant portion of the world's gem-quality diamond produced each year, and they also purchase diamonds from Russia. In 2009, De Beers companies produced 23.6 million carats, a 49% decrease from 2008 production. De Beers companies also sorted and valuated a large portion (by value) of the world's annual supply of rough diamond through De Beers' subsidiary Diamond Trading Co. (DTC), which had marketing agreements with other producers. In 2009, De Beers had diamond sales of $3.84 billion, which was a decrease of 44.3% from diamond sales of $6.89 billion in 2008 (De Beers Group, 2009, p. 17; 2010; National Jeweler, 2010a).

Foreign Trade

During 2009, total U.S. gemstone trade with all countries and territories was valued at about $23.8 billion, which was a decrease of 34% from that of 2008. Diamond accounted for about 94% of the 2009 gemstone trade total. In 2009, U.S. exports and reexports of diamond were shipped to 94 countries and territories, and imports of all gemstones were received from 100 countries and territories (tables 6–10). In 2009, U.S. import quantities in cut diamond decreased by 16%, compared with those of 2008. U.S. imports in rough and unworked diamond decreased by 4% (table 7). The United States remained the world's leading diamond importer and was a significant international diamond transit center as well as the world's leading gem-quality diamond market. In 2009, U.S. export quantities of gem-grade diamond decreased by 54% compared with those of 2008. The large volume of reexports shipped to other centers revealed the significance that the United States had in the world's diamond supply network (table 6). These decreases in trade were owing to the impact of the recession on luxury spending.

Import values of laboratory-created gemstone decreased by 21% for the United States in 2009 compared with those of 2008 (table 10). Again, this decrease in imports was owing to the impact of the recession on luxury spending.

Laboratory-created gemstone imports from Austria, China, Germany, India, Switzerland, and Thailand, with more than $500,000 in imports each, made up about 82% (by value) of the total domestic imports of laboratory-created gemstones during the year (table 9). The marketing of imported laboratory-created gemstones and enhanced gemstones as natural gemstones, and the mixing of laboratory-created materials with natural stones in imported parcels, continued to be problems for some domestic producers in 2009. There also were continuing problems with some simulants being marketed as laboratory-created gemstones during the year.

World Review

The gemstone industry worldwide has two distinct sectors—diamond mining and marketing and colored gemstone production and sales. Most diamond supplies are controlled by a few major mining companies; prices are supported by managing the quality and quantity of the gemstones relative to demand, a function performed by De Beers through DTC. Unlike diamond, colored gemstones are primarily produced at relatively small, low-cost operations with few dominant producers; prices are influenced by consumer demand and supply availability.

In 2009, world natural diamond production totaled about 129 million carats—74.1 million carats gem quality and 54.6 million carats industrial grade (table 11). Most production was concentrated in a few regions—Africa [Angola, Botswana, Congo (Kinshasa), Namibia, and South Africa], Asia (northeastern Siberia and Yakutia in Russia), Australia, North America (Northwest Territories in Canada), and South America (Brazil and Venezuela). In 2009, Russia led the world in total natural diamond output quantity (combined gemstone and industrial) with 25% of the world estimated production. Botswana was the world's leading gemstone diamond producer, followed by Russia, Canada, Angola, Congo (Kinshasa), Guinea, South Africa, and Namibia in descending order of quantity. These eight countries produced 96% (by quantity) of the world's gemstone diamond output in 2009.

In 2002, the international rough-diamond certification system, the Kimberley Process Certification Scheme (KPCS), was agreed upon by United Nations (UN) member nations, the diamond industry, and involved nongovernmental organizations to prevent the shipment and sale of conflict diamonds. Conflict diamonds are diamonds that originate from areas controlled by forces or factions opposed to legitimate and internationally recognized governments, and are used to fund military action in opposition to those governments, or in contravention of the decisions of the U.N. Security Council. The KPCS includes the following key elements: the use of forgery-resistant certificates and tamper-proof containers for shipments of rough diamonds; internal controls and procedures that provide credible assurance that conflict diamonds do not enter the legitimate diamond market; a certification process for all exports of rough diamonds; the gathering, organizing, and sharing of import and export data on rough diamonds with other participants of relevant production; credible monitoring and oversight of the international certification scheme for rough diamonds; effective enforcement of the provisions of the certification scheme through dissuasive and proportional penalties for violations; self regulation by the diamond industry that fulfills minimum requirements; and sharing information with all other participants on relevant rules, procedures, and legislation as well as examples of national certificates used to accompany shipments of rough diamonds (Weldon, 2001). Namibia assumed the chair of KPCS for the period from January 1 through December 31, 2009. Namibia was the seventh in succession to hold the chair after India, South Africa, Canada, Russia, Botswana, and the European Commission (Kimberley Process, 2008a; 2008b). The list of 49 participants, represented 75 nations (including the 27 member nations of the European Community) plus the rough diamond-trading entity of Taipei. During 2009, Cote d' Ivoire was under UN sanctions and was prohibited from trading in rough diamonds; and Venezula voluntarily separated from the KPCS and ceased certification for export of its rough diamonds. In 2009, the KPCS also monitored the diamond sector in Zimbabwe after a diamond rush in 2007 threatened the country's KPCS system, and there were indications of smuggling and reports of violence. The KPCS had engaged Zimbabwean authorities and were working with them to strengthen their certification scheme and help Zimbabwe meet their obligations to the KPCS. The participating nations in the KPCS account for approximately 98% of the global production and trade of rough diamonds (Kimberley Process, 2009a; 2009b).

Globally, the value of production of natural gemstones other than diamond was estimated to be about $2 billion in 2009. Most nondiamond gemstone mines are small, low-cost, and widely dispersed operations in remote regions of developing nations. Foreign countries with major gemstone deposits other than diamond are Afghanistan (aquamarine, beryl, emerald, kunzite, lapis lazuli, ruby, and tourmaline), Australia (beryl, opal, and sapphire), Brazil (agate, amethyst, beryl, ruby, sapphire, topaz, and tourmaline), Burma (beryl, jade, ruby, sapphire, and topaz), Colombia (beryl, emerald, and sapphire), Kenya (beryl, garnet, and sapphire), Madagascar (beryl, rose quartz, sapphire, and tourmaline), Mexico (agate, opal, and topaz), Sri Lanka (beryl, ruby, sapphire, and topaz), Tanzania (garnet, ruby, sapphire, tanzanite, and tourmaline), and Zambia (amethyst and beryl). In addition, pearls are cultured throughout the South Pacific and in other equatorial waters; Australia, China, French Polynesia, and Japan were key producers in 2009.

Worldwide in 2009, three small diamond mines and two expansion projects started up. Three of the startups were in Russia, and two were in Guinea (Metals Economics Group, 2010, p. 14).

Burma.—Gemstone sanctions against Burma by the international community, which began in 2008, seemed to be having an effect. Total Burmese gemstone production in 2009 was reported to have decreased by 46% from that of 2008. There was not an increase in gem production in any category except for pearls. Burmese jade production decreased 18% in 2009 from that of 2008, pearl production increased by 5%, peridot production decreased by 66%, ruby decreased by 10%, sapphire decreased by 30%, and spinel decreased by 48%. Gemstone trade was down with all countries participating in the sanctions. Burmese gemstone trade with China, which was not participating in the sanctions, increased in 2009 by 10% from that of 2008. In the United States, the Burmese gemstone sanctions were brought about by the Burma Jade Act of 2008, which was enacted and reported on in the 2008 Gemstone Minerals Yearbook report (Sapora, 2010).

Canada.—Canadian diamond production was more than 10.9 million carats (Mct) with an estimated value of $1.7 billion during 2009, a decrease of about 26% compared with that of 2008. Diamond exploration continued in Canada, with several commercial diamond projects and additional discoveries in Alberta, British Columbia, the Northwest Territories, Nunavut, Ontario, and Quebec. In 2009, Canada produced 15% of the world's natural gemstone diamond output.

The Ekati Diamond Mine, Canada's first operating commercial diamond mine, completed its 11th full year of production in 2009. Ekati produced 4.2 Mct of diamond from 5.10 million metric tons (Mt) of ore. BHP Billiton Ltd. has an 80% controlling ownership in Ekati, which is in the Northwest Territories. Ekati has estimated remaining reserves of 38.5 Mt of ore in kimberlite pipes that contain 18.3 Mct of diamond. BHP Billiton projected the remaining mine life to be 13 years. Approximately 79% of the Ekati 2009 diamond production was gem-grade material (BHP Billiton Ltd., 2010, p. 10; Perron, 2011, p. 1).

The Diavik Diamond Mine, Canada's second diamond mine, also located in the Northwest Territories, completed its seventh full year of production. In 2009, Diavik produced 5.6 million carats of diamond, a decrease of 40% from the previous year's production. This lower production was a consequence of a reduced operating level at the mine intended to balance production with lower market demand that resulted from the downturn in the economy that began in mid-2008. Diavik reacted by temporarily ceasing diamond production at the Diavik Mine between July 14 and August 24, 2009. During this time period, the Diavik Mine was placed on a care-and-maintenance schedule. At yearend 2009, Diavik Diamond Mines estimated the mine's remaining proven and probable reserves to be 19.7 Mt of ore in kimberlite pipes containing 59.1 million carats of diamond and projected the total mine life to be 16 to 22 years. During 2009, Diavik began developing an underground mine, and construction on the underground project was substantially completed during 2009. First ore was expected during the first quarter of 2010, with full production expected in 2013. The mine is an unincorporated joint venture between Diavik Diamond Mines Inc. (60%) and Harry Winston Diamond Mines Ltd. (40%) (Diavik Diamond Mines Inc., 2010; Perron, 2011, p. 2).

Canada's third diamond mine, the Jericho Diamond Mine, is located in Nunavut and was owned by Tahera Diamond Corp. Tahera estimated the Jericho Diamond Mine's reserves to be about 5.5 Mt of ore grading 0.85 carats per ton. The Jericho Diamond Mine experienced startup problems related to ore mining and processing. The mine also suffered financial problems owing to the cost of transporting supplies to the mine site, higher operational costs, higher oil prices, and appreciation of the Canadian dollar versus the U.S. dollar. All of these problems combined to force the company to enter into protection under Canada's "Companies' Creditors Arrangement Act" on January 16, 2008, and the mine suspended production on February 6, 2008. As a result, the mine's 2008 production was only 118,000 carats. At yearend 2009, Tahera was finalizing arrangements to sell all its Jericho mine assets (Perron, 2011, p. 2).

The Snap Lake Mine, which is wholly owned by De Beers Canada Inc., is in the Northwest Territories. The Snap Lake deposit is a tabular-shaped kimberlite dike rather than the typical kimberlite pipe. The dike is 2.7 meters thick and dips at an angle of 15°. The deposit was mined using a modified room and pillar underground mining method in 2009. The Snap Lake Mine started mining operations in October 2007, reached commercial production levels in the first quarter of 2008, and officially opened June 25, 2008. The mine was expected to produce 1.4 Mct per year of diamond, and the mine life was expected to be about 20 years. De Beers suspended production for 6 weeks in July and August 2009. This production suspension was scheduled to align production levels with market demand. The mine's production for the year was 440,000 carats, for a recovered grade of 1.25 carats per ton (Perron, 2011, p. 2–3).

The Victor Mine, which also is wholly owned by De Beers Canada, is in northern Ontario on the James Bay coast. The Victor kimberlite consists of two pipes with surface area of 15 hectares (37.1 acres). The Victor Mine initiated mining operations at the end of December 2007 and officially opened on July 26, 2008. The Victor deposit reportedly holds 27.4 Mt of ore with average ore grade of 0.23 carats per ton. At full capacity, the open pit mine was expected to produce 600,000 carats per year, and the mine life was expected to be about 12 years. De Beers also suspended production at this mine for 6 weeks in July and August. In 2009, the mine's production was 696,000 carats valued at $244 million and had an average recovery grade of 0.33 carats per ton (Perron, 2011, p. 3).

China.—During 2009, China became the world's second largest diamond market, following the United States and replacing Japan. The Chinese Government reported that 2009 diamond imports were more than $1.5 billion (National Jeweler, 2010b).

Guinea.—The Mandala alluvial mine, owned by Stellar Diamonds Plc, was producing with positive cash flow at 60% of capacity by yearend 2009. During 2010, the mine's output was expected to be 140,000 carats. Stellar estimated that the deposit contains 536,000 carats of diamond in 1.41 Mt of resources, grading 0.38 carats per ton (Metals Economics Group, 2010, p. 14–15).

Another alluvial mine, Bomboko, owned by West African Diamonds Plc, had increased production to 1,500 carats per month from 35,000 tons per month of ore by October 2009. Visual inspection of stones produced indicated that about 60% was gem quality and 40% was industrial grade. West African estimated that the deposit contains 750,000 carats of diamond in 25 Mt of resources grading 0.03 carats per ton (Metals Economics Group, 2010, p. 14–15).

Russia.—In 2009, Russia was again the world's leading producer of combined natural gemstone and industrial diamonds as it has been every year since 2004. Russian natural diamond production was 32.8 Mct with an estimated value of $2.34 billion, a decrease of about 11% compared with that of the previous year (Metals Economics Group, 2011, p. 12).

The largest mine that came online in 2009 was the underground development of the Arkangelskaya pipe at the Lomonosov Mine in northwestern Russia. Lomonosov started mining the Arkangelskaya pipe in September at 1 million tons per year (Mt/yr) of ore and was estimated to have an optimum production capacity of 4 Mt/yr of ore. Lomonosov is 95% owned by ALROSA Co. Ltd. and 5% owned by the Government of Russia. Lomonosov was estimated to have 27.3 Mct of diamonds contained in 54.8 Mt of ore, grading at an estimated 0.5 carats per ton. The estimated mine life was 17 years, with materials coming from the Arkangelskaya and Karpinskogo-1 pipes (Metals Economics Group, 2010, p. 14–15).

The Mirny Division of Alrosa in Yakutia officially opened the Mir underground mine in August. The Mir was expected to yield 500,000 carats of diamonds from 1 Mt/yr of ore during a projected 50-year mine life. Alrosa had future plans for two additional underground operations parallel to Mir, that would provide an additional 4.5 Mt/yr of ore (Metals Economics Group, 2010, p. 14–15).

A third new mine owned by Alrosa was the Aikhal underground mine in Yakutia. Aikhal began commercial production in December 2009. The mine was estimated to contain 1.25 Mct of diamonds in 12.5 Mt of ore grading 0.10 carats per ton. Aikhal had an estimated 25-year mine life (Metals Economics Group, 2010, p. 14–15).

South Africa.—On September 24, 2009, a rough 507.55-carat (just more than 100 grams) white diamond was mined at the historic Cullinan Mine, where the famous Cullinan diamond (the largest diamond found in recorded history) was discovered in 1905. The Cullinan Mine is owned by Petra Diamonds Cullinan Consortium, whose spokesman said that the gemstone was among the world's 20 largest diamonds ever discovered. Initial examinations of the stone indicated that it is of exceptional color and clarity, and most likely a Type I diamond. The diamond was found with three other exceptionally valuable diamonds, a 168-carat gemstone and two other stones that weighed 58.5 and 53.3 carats. The Cullinan Mine is also the world's primary source for blue diamonds. In May 2009, a fancy vivid blue diamond weighing 7.03 carats (cut from 26.58-carat rough diamond) found at the Cullinan Mine sold for $9.4 million. This was the highest price ever paid for a gemstone sold at auction (Maclean, 2009; Reinke, 2009).

Outlook

As the domestic and global economy improves, Internet sales of diamonds, gemstones, and jewelry were expected to continue to grow and increase in popularity, as were other forms of e-commerce that emerge to serve the diamond and gemstone industry. This is likely to take place as the gemstone industry and its customers become more comfortable with and learn the applications of new e-commerce tools (Profile America, Inc., 2008).

Independent producers, such as Ekati and Diavik in Canada, will likely continue to bring a greater measure of competition to global markets. More competition presumably will bring more supplies and lower prices. Further consolidation of diamond producers and larger quantities of rough diamond being sold outside DTC is expected to continue as the diamond industry adjusts to De Beers' reduced influence on the industry.

More laboratory-created gemstones, simulants, and treated gemstones are likely to enter the marketplace and necessitate more transparent trade industry standards to maintain customer confidence.

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TABLE 1

GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Amber	Hydrocarbon	Yellow, red, green, blue	Any	Low to medium	2.0–2.5	1.0–1.1	Single	1.54	Synthetic or pressed plastics, kaurigum	Fossil resin, color, low density, soft, insects.
Apatite	Chlorocalcium phosphate	Colorless, pink, yellow, green, blue, violet	Small	Low	5.0	3.16–3.23	Double	1.63–1.65	Amblygonite, andalusite, brazilianite, precious beryl, titanite, topaz, tourmaline	Crystal habit, color, hardness, appearance.
Azurite	Copper carbonate hydroxide	Azure, dark blue, pale blue	Small to medium	do.	3.5–4.0	3.7–3.9	do.	1.72–1.85	Dumortierite, hauynite, lapis lazuli, lazulite, sodalite	Color, softness, crystal habits, associated minerals.
Benitoite	Barium titanium silicate	Blue, purple, pink, colorless	do.	High	6.0–6.5	3.64–3.68	do.	1.76–1.80	Sapphire, tanzanite, blue diamond, blue tourmaline, cordierite	Strong blue in ultraviolet light.
Beryl:										
Aquamarine	Beryllium aluminum silicate	Blue-green to light blue	Any	Medium to high	7.5–8.0	2.63–2.80	do.	1.58	Synthetic spinel, blue topaz	Double refraction, refractive index.
Bixbite	do.	Red	Small	Very high	7.5–8.0	2.63–2.80	do.	1.58	Pressed plastics, tourmaline	Refractive index.
Emerald, natural	do.	Green	Medium	do.	7.5	2.63–2.80	do.	1.58	Fused emerald, glass, tourmaline, peridot, green garnet doublets	Emerald filter, dichroism, refractive index.
Emerald, synthetic	do.	do.	Small	High	7.5–8.0	2.63–2.80	do.	1.58	Genuine emerald	Lack of flaws, brilliant fluorescence in ultraviolet light.
Golden (heliodor)	do.	Yellow to golden	Any	Low to medium	7.5–8.0	2.63–2.80	do.	1.58	Citrine, topaz, glass, doublets	Weak-colored.
Goshenite	do.	Colorless	do.	Low	7.5–8.0	2.63–2.80	do.	1.58	Quartz, glass, white sapphire, white topaz	Refractive index.
Morganite	do.	Pink to rose	do.	do.	7.5–8.0	2.63–2.80	do.	1.58	Kunzite, tourmaline, pink sapphire	Do.
Calcite:										
Marble	Calcium carbonate	White, pink, red, blue, green, or brown	do.	do.	3.0	2.72	Double (strong)	1.49–1.66	Silicates, banded agate, alabaster gypsum	Translucent.
Mexican onyx	do.	do.	do.	do.	3.0	2.72	do.	1.60	do.	Banded, translucent.
Charoite	Hydrated sodium calcium hydroxi-fluoro-silicate	Lilac, violet, or white	Small to medium	do.	5.0–6.0	2.54–2.78	XX	1.55–1.56	Purple marble	Color, locality.

See footnotes at end of table.

TABLE 1—Continued
GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Chrysoberyl:										
Alexandrite	Beryllium aluminate	Green by direct sunlight, or encandescent light, red by indirect sunlight or fluorescent light	Small to medium	High	8.5	3.50–3.84	Double	1.75	Synthetic	Strong dichroism, color varies from red to green, hardness.
Cat's eye	Beryllium aluminate	Greenish to brownish	Small to large	High	8.5	3.50–3.84	Double	1.75	Synthetic, shell	Density, translucence, chatoyance.
Chrysolite	do.	Yellow, green, and (or) brown	Medium	Medium	8.5	3.50–3.84	do.	1.75	Tourmaline, peridot	Refractive index, silky.
Chrysocolla	Hydrated copper silicate	Green, blue	Any	Low	2.0–4.0	2.0–2.4	XX	1.46–1.57	Azurite, dyed chalcedony, malachite, turquoise, variscite	Lack of crystals, color, fracture, low density, softness.
Coral	Calcium carbonate	Orange, red, white, black, purple, or green	Branching, medium	do.	3.5–4.0	2.6–2.7	Double	1.49–1.66	False coral	Dull translucent.
Corundum:										
Ruby	Aluminum oxide	Rose to deep purplish red	Small	Very high	9.0	3.95–4.10	do.	1.78	Synthetics, including spinel, garnet	Inclusions, fluorescence.
Sapphire, blue	do.	Blue	Medium	High	9.0	3.95–4.10	do.	1.78	do.	Inclusions, double refraction, dichroism.
Sapphire, fancy	do.	Yellow, pink, colorless, orange, green, or violet	Medium to large	Medium	9.0	3.95–4.10	do.	1.78	Synthetics, glass and doublets, morganite	Inclusions, double refraction, refractive index.
Sapphire or ruby, stars	do.	Red, pink, violet, blue, or gray	do.	High to low	9.0	3.95–4.10	do.	1.78	Star quartz, synthetic stars	Shows asterism, color side view.
Sapphire or ruby, synthetic	do.	Yellow, pink, blue, green, orange, violet, or red	Up to 20 carats	Low	9.0	3.95–4.10	do.	1.78	Synthetic spinel, glass	Curved striae, bubble inclusions.
Cubic zirconia	Zirconium and yttrium oxides	Colorless, pink, blue, lavender, yellow	Small	do.	8.25–8.5	5.8	Single	2.17	Diamond, zircon, titania, moissanite	Hardness, density, lack of flaws and inclusions, refractive index.
Diamond	Carbon	White, blue-white, yellow, brown, green, red, pink, blue	Any	Very high	10.0	3.516–3.525	do.	2.42	Zircon, titania, cubic zirconia, moissanite	High index, dispersion, hardness, luster.
Feldspar:										
Amazonite	Alkali aluminum silicate	Green-blue	Large	Low	6.0–6.5	2.56	XX	1.52	Jade, turquoise	Cleavage, sheen, vitreous to pearly, opaque, grid.
Labradorite	do.	Gray with blue and bronze sheen color play (schiller)	do.	do.	6.0–6.5	2.56	XX	1.56	do.	Do.

See footnotes at end of table.

TABLE 1—Continued

GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Moonstone	do.	Colorless, white, gray, or yellow with white, blue, or bronze schiller	do.	do.	6.0–6.5	2.77	XX	1.52–1.54	Glass, chalcedony, opal	Pale sheen, opalescent.
Sunstone	do.	Orange, red brown, colorless with gold or red glittery schiller	Small to medium	do.	6.0–6.5	2.77	XX	1.53–1.55	Aventurine, glass	Red glittery schiller.
Garnet	Complex silicate	Brown, black, yellow, green, red, or orange	Small to medium	Low to high	6.5–7.5	3.15–4.30	Single strained	1.79–1.98	Synthetics, spinel, glass	Single refraction, anomalous strain.
Hematite	Iron oxide	Black, black-gray, brown-red	Medium to large	Low	5.5–6.5	5.12–5.28	XX	2.94–3.22	Davidite, cassiterite, magnetite, neptunite, pyrolusite, wolframite	Crystal habit, streak, hardness.
Jade:										
Jadeite	Complex silicate	Green, yellow, black, white, or mauve	Large	Low to very high	6.5–7.0	3.3–3.5	Crypto-crystalline	1.65–1.68	Nephrite, chalcedony, onyx, bowenite, vesuvianite, grossularite	Luster, spectrum, translucent to opaque.
Nephrite	Complex hydrous silicate	do.	do.	do.	6.0–6.5	2.96–3.10	do.	1.61–1.63	Jadeite, chalcedony, onyx, bowenite, vesuvianite, grossularite	Do.
Jet (gagate)	Lignite	Deep black, dark brown	do.	Low	2.5–4.0	1.19–1.35	XX	1.64–1.68	Anthracite, asphalt, cannel coal, onyx, schorl, glass, rubber	Luster, color.
Lapis lazuli	Sodium calcium aluminum silicate	Dark azure-blue to bright indigo blue or even a pale sky blue.	do.	do.	5.0–6.0	2.50–3.0	XX	1.50	Azurite, dumortierite, dyed howlite, lazulite, sodalite, glass	Color, crystal habit, associated minerals, luster, localities.
Malachite	Hydrated copper carbonate	Light to black-green banded	do.	do.	3.5–4.0	3.25–4.10	XX	1.66–1.91	Brochantite, chrysoprase, opaque green gemstones	Color banding, softness, associated minerals.
Moissanite	Silicon carbide	Colorless and pale shades of green, blue, yellow	Small	Low to medium	9.25	3.21	Double	2.65–2.69	Diamond, zircon, titania, cubic zirconia	Hardness, dispersion, lack of flaws and inclusions, refractive index.
Obsidian	Amorphous, variable (usually felsic)	Black, gray, brown, dark green, white, transparent	Large	Low	5.0–5.5	2.35–2.60	XX	1.45–1.55	Aegirine-augite, gadolinite, gagate, hematite, pyrolusite, wolframite	Color, conchoidal fracture, flow bubbles, softness, lack of crystal faces.
Opal	Hydrated silica	Reddish orange, colors flash in white gray, black, red, or yellow	do.	Low to high	5.5–6.5	1.9–2.3	Single	1.45	Glass, synthetics, triplets, chalcedony	Color play (opalescence).

See footnotes at end of table.

TABLE 1—Continued
GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Peridot	Iron magnesium silicate	Yellow and (or) green	Any	Medium	6.5–7.0	3.27–3.37	Double (strong)	1.65–1.69	Tourmaline, chrysoberyl	Strong double refraction, low dichroism.
Quartz:										
Agate	Silicon dioxide	Any	Large	Low	7.0	2.58–2.64	XX	XX	Glass, plastic, Mexican onyx	Cryptocrystalline, irregularly banded, dendritic inclusions.
Amethyst	do.	Purple	Large	Medium	7.0	2.65–2.66	Double	1.55	Glass, plastic, fluorite	Macrocrystalline, color, refractive index, transparent, hardness.
Aventurine	do.	Green, red-brown, gold-brown, with metallic iridescent reflection	do.	Low	7.0	2.64–2.69	do.	1.54–1.55	Iridescent analcime, aventurine feldspar, emerald, aventurine glass	Macrocrystalline, color, metallic iridescent flake reflections, hardness.
Cairngorm	do.	Smoky orange or yellow	do.	do.	7.0	2.65–2.66	do.	1.55	do.	Macrocrystalline, color, refractive index, transparent, hardness.
Carnelian	do.	Flesh red to brown red	do.	do.	6.5–7.0	2.58–2.64	do.	1.53–1.54	Jasper	Cryptocrystalline, color, hardness.
Chalcedony	do.	Bluish, white, gray	do.	do.	6.5–7.0	2.58–2.64	do.	1.53–1.54	Tanzanite	Do.
Chrysoprase	do.	Green, apple-green	do.	do.	6.5–7.0	2.58–2.64	do.	1.53–1.54	Chrome chalcedony, jade, prase opal, prehnite, smithsonite, variscite, artifically colored green chalcedony	Do.
Citrine	do.	Yellow	do.	do.	7.0	2.65–2.66	do.	1.55	do.	Macrocrystalline, color, refractive index, transparent, hardness.
Jasper	do.	Any, striped, spotted, or sometimes uniform	do.	do.	7.0	2.58–2.66	XX	XX	do.	Cryptocrystalline, opaque, vitreous luster, hardness.
Onyx	do.	Many colors	do.	do.	7.0	2.58–2.64	XX	XX	do.	Cryptocrystalline, uniformly banded, hardness.
Petrified wood	do.	Brown, gray, red, yellow	do.	do.	6.5–7.0	2.58–2.91	Double	1.54	Agate, jasper	Color, hardness, wood grain.
Rock crystal	do.	Colorless	do.	do.	7.0	2.65–2.66	do.	1.55	Topaz, colorless sapphire	Do.

See footnotes at end of table.

TABLE 1—Continued

GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Rose	do.	Pink, rose red	do.	do.	7.0	2.65–2.66	do.	1.55	do.	Macrocrystalline, color, refractive index, transparent, hardness.
Tiger's eye	do.	Golden yellow, brown, red, blue-black	do.	do.	6.5–7.0	2.58–2.64	XX	1.53–1.54	XX	Macrocrystalline, color, hardness, hatoyancy.
Rhodochrosite	Manganese carbonate	Rose-red to yellowish, stripped	Large	Low	4.0	3.45–3.7	Double	1.6–1.82	Fire opal, rhodonite, tugtupite, tourmaline	Color, crystal habit, reaction to acid, perfect rhombohedral cleavage.
Rhodonite	Manganese iron calcium silicate	Dark red, flesh red, with dendritic inclusions of black manganese oxide	do.	do.	5.5–6.5	3.40–3.74	do.	1.72–1.75	Rhodochrosite, thulite, hessonite, spinel, pyroxmangite, spessartine, tourmaline	Color, black inclusions, lack of reaction to acid, hardness.
Shell:										
Mother-of-pearl	Calcium carbonate	White, cream, green, blue-green, with iridescent play of color	Small	do.	3.5	2.6–2.85	XX	XX	Glass and plastic imitation	Luster, iridescent play of color.
Pearl	do.	White, cream to black, sometimes with hint of pink, green, purple	do.	Low to high	2.5–4.5	2.6–2.85	XX	XX	Cultured and glass or plastic imitation	Luster, iridescence, x-ray of internal structure.
Spinel, natural	Magnesium aluminum oxide	Any	Small to medium	Medium	8.0	3.5–3.7	Single	1.72	Synthetic, garnet	Refractive index, single refraction, inclusions.
Spinel, synthetic	do.	do.	Up to 40 carats	Low	8.0	3.5–3.7	Double	1.73	Spinel, corundum, beryl, topaz, alexandrite	Weak double refraction, curved striae, bubbles.
Spodumene:										
Hiddenite	Lithium aluminum silicate	Yellow to green	Medium	Medium	6.5–7.0	3.13–3.20	do.	1.66	Synthetic spinel	Refractive index, color, pleochroism.
Kunzite	do.	Pink to lilac	do.	do.	6.5–7.0	3.13–3.20	do.	1.66	Amethyst, morganite	Do.
Tanzanite	Complex silicate	Blue to lavender	Small	High	6.0–7.0	3.30	do.	1.69	Sapphire, synthetics	Strong trichroism, color.
Topaz	do.	White, blue, green, pink, yellow, gold	Medium	Low to medium	8.0	3.4–3.6	do.	1.62	Beryl, quartz	Color, density, hardness, refractive index, perfect in basal cleavage.
Tourmaline	do.	Any, including mixed	do.	do.	7.0–7.5	2.98–3.20	do.	1.63	Peridot, beryl, garnet corundum, glass	Double refraction, color, refractive index.
Turquoise	Copper aluminum phosphate	Blue to green with black, brown-red inclusions	Large	Low	6.0	2.60–2.83	do.	1.63	Chrysocolla, dyed howlite, dumortierite, glass, plastics, variscite	Difficult if matrix not present, matrix usually limonitic.
Unakite	Granitic rock, feldspar, epidote, quartz	Olive green, pink, and blue-gray	do.	do.	6.0–7.0	2.60–3.20	XX	XX	XX	Olive green, pink, gray-blue colors.

See footnotes at end of table.

TABLE 1—Continued
GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Zircon	Zirconium silicate	White, blue, brown, yellow, or green	Small to medium	Low to medium	6.0–7.5	4.0–4.8	Double (strong)	1.79–1.98	Diamond, synthetics, topaz, aquamarine	Double refraction, strongly dichroic, wear on facet edges.

Do., do. Ditto. XX Not applicable.

[1] Small: up to 5 carats; medium: 5 to 50 carats; large: more than 50 carats.

[2] Low: up to $25 per carat; medium: up to $200 per carat; high: more than $200 per carat.

TABLE 2
LABORATORY-CREATED GEMSTONE PRODUCTION METHODS

Gemstone	Production method	Company/producer	Date of first production
Alexandrite	Flux	Creative Crystals Inc.	1970s.
Do.	Melt pulling	J.O. Crystal Co., Inc.	1990s.
Do.	do.	Kyocera Corp.	1980s.
Do.	Zone melt	Seiko Corp.	Do.
Cubic zirconia	Skull melt	Various producers	1970s.
Emerald	Flux	Chatham Created Gems	1930s.
Do.	do.	Gilson	1960s.
Do.	do.	Kyocera Corp.	1970s.
Do.	do.	Lennix	1980s.
Do.	do.	Russia	Do.
Do.	do.	Seiko Corp.	Do.
Do.	Hydrothermal	Biron Corp.	Do.
Do.	do.	Lechleitner	1960s.
Do.	do.	Regency	1980s.
Do.	do.	Russia	Do.
Ruby	Flux	Chatham Created Gems	1950s.
Do.	do.	Douras	1990s.
Do.	do.	J.O. Crystal Co., Inc.	1980s.
Do.	do.	Kashan Created Ruby	1960s.
Do.	Melt pulling	Kyocera Corp.	1970s.
Do.	Verneuil	Various producers	1900s.
Do.	Zone melt	Seiko Corp.	1980s.
Sapphire	Flux	Chatham Created Gems	1970s.
Do.	Melt pulling	Kyocera Corp.	1980s.
Do.	Verneuil	Various producers	1900s.
Do.	Zone melt	Seiko Corp.	1980s.
Star ruby	Melt pulling	Kyocera Corp.	Do.
Do.	do.	Nakazumi Earth Crystals Co.	Do.
Do.	Verneuil	Linde Air Products Co.	1940s.
Star sapphire	do.	do.	Do.

Do., do. Ditto.

TABLE 3
ESTIMATED VALUE OF U.S. NATURAL GEMSTONE PRODUCTION, BY GEM TYPE[1]

(Thousand dollars)

Gem materials	2008	2009
Beryl	18	18
Coral, all types	150	150
Diamond	(2)	(2)
Garnet	130	148
Gem feldspar	916	858
Geode/nodules	91	105
Opal	357	225
Quartz:		
Macrocrystalline[3]	334	231
Cryptocrystalline[4]	344	216
Sapphire/ruby	556	256
Shell	2,290	713
Topaz	(2)	(2)
Tourmaline	112	112
Turquoise	508	531
Other	5,670	4,850
Total	11,500	8,410

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Included with "Other."

[3] Macrocrystalline quartz (crystals recognizable with the naked eye) includes amethyst, aventurine, blue quartz, citrine, hawk's eye, pasiolite, prase, quartz cat's eye, rock crystal, rose quartz, smoky quartz, and tiger's eye.

[4] Cryptocrystalline quartz (microscopically small crystals) includes agate, carnelian, chalcedony, chrysoprase, fossilized wood, heliotrope, jasper, moss agate, onyx, and sard.

TABLE 4
PRICES PER CARAT OF U.S. CUT ROUND DIAMONDS, BY SIZE AND QUALITY IN 2009

Carat	Description,	Clarity[2]	Representative prices		
weight	color[1]	(GIA terms)	January[3]	June[4]	December[5]
0.25	G	VS1	$1,495	$1,430	$1,430
Do.	G	VS2	1,350	1,325	1,325
Do.	G	SI1	1,200	1,125	1,125
Do.	H	VS1	1,400	1,300	1,300
Do.	H	VS2	1,300	1,190	1,190
Do.	H	SI1	1,070	1,050	1,050
0.50	G	VS1	3,200	2,775	2,775
Do.	G	VS2	2,800	2,350	2,350
Do.	G	SI1	2,400	1,875	1,875
Do.	H	VS1	2,800	2,400	2,400
Do.	H	VS2	2,400	2,050	2,050
Do.	H	SI1	2,200	1,725	1,725
1.00	G	VS1	6,500	6,075	6,075
Do.	G	VS2	6,100	5,400	5,400
Do.	G	SI1	5,000	4,575	4,575
Do.	H	VS1	5,500	5,100	5,100
Do.	H	VS2	5,300	4,650	4,650
Do.	H	SI1	4,600	4,350	4,350
2.00	G	VS1	12,300	12,300	12,300
Do.	G	VS2	10,900	10,900	10,900
Do.	G	SI1	9,400	9,400	9,400
Do.	H	VS1	10,200	10,200	10,200
Do.	H	VS2	9,400	9,400	9,400
Do.	H	SI1	7,900	7,900	7,900

Do. Ditto.

[1] Gemological Institute of America (GIA) color grades: D-colorless; E-rare white; G, H, I-traces of color.

[2] Clarity: IF—no blemishes; VVS1—very, very slightly included; VS1—very slightly included; VS2—very slightly included, but not visible; SI1—slightly included.

[3] Source: Jewelers' Circular Keystone, v. 180, no. 2, February 2009, p. 59.

[4] Source: Jewelers' Circular Keystone, v. 180, no. 7, July 2009, p. 41.

[5] Source: Jewelers' Circular Keystone, v. 181, no. 1, January 2010, p. 54.

TABLE 5
PRICES PER CARAT OF U.S. CUT COLORED GEMSTONES IN 2009

Gemstone	Price range per carat	
	January[1]	December[2]
Amethyst	$10–25	$10–25
Blue sapphire	825–1,650	900–1,650
Blue topaz	5–10	5–10
Emerald	2,400–4,000	2,400–4,000
Green tourmaline	50–70	50–70
Cultured saltwater pearl[3]	5	5
Pink tourmaline	60–135	70–150
Rhodolite garnet	20–40	20–40
Ruby	1,850–2,200	1,850–2,200
Tanzanite	300–475	300–375

[1] Source: The Gem Guide—Color, spring/summer 2009, p. 22, 37, 51, 65, 74, 85, 96, 98, 104, and 119. These figures are approximate wholesale purchase prices paid by retail jewelers on a per stone basis for 1-to-less than 1 carat, fine-quality stones.

[2] Source: The Gem Guide, November/December 2009, p. 44, 47, 51, 55, 57, 59, 62, 63, 64, and 65. These figures are approximate wholesale purchase prices paid by retail jewelers on a per stone basis for 1-to-less than 1 carat, fine-quality stones.

[3] Prices are per 4.5 to 5-millimeter pearl.

TABLE 6
U.S. EXPORTS AND REEXPORTS OF DIAMOND (EXCLUSIVE OF INDUSTRIAL DIAMOND), BY COUNTRY[1]

Country	2008 Quantity (carats)	2008 Value[2] (millions)	2009 Quantity (carats)	2009 Value[2] (millions)
Exports:				
Australia	103,000	$18	37,600	$21
Belgium	1,600,000	685	300,000	150
Canada	79,700	116	46,600	70
Costa Rica	55,200	6	8,470	2
France	136,000	136	49,200	25
Hong Kong	1,340,000	814	807,000	380
India	1,480,000	1,220	962,000	477
Israel	2,650,000	2,130	960,000	482
Japan	54,800	12	17,800	5
Mexico	678,000	110	504,000	79
Netherlands	19,000	3	561	1
Netherlands Antilles	16,200	35	10,600	23
Singapore	98,500	19	31,200	13
South Africa	31,400	4	829	2
Switzerland	99,400	270	152,000	146
Taiwan	15,000	12	12,900	5
Thailand	226,000	54	86,700	40
United Arab Emirates	165,000	115	108,000	46
United Kingdom	121,000	84	27,400	58
Other	248,000	103	156,000	133
Total	9,210,000	5,940	4,280,000	2,160
Reexports:				
Armenia	13,400	(3)	1,670	(3)
Australia	33,800	14	59,600	19
Belgium	5,790,000	1,890	4,130,000	1,110
Canada	230,000	195	139,000	127
Dominican Republic	61,400	12	15,300	3
France	30,500	23	80,800	43
Guatemala	104,000	14	50,300	5
Hong Kong	2,680,000	1,350	3,220,000	1,190
India	2,250,000	482	2,350,000	959
Israel	10,200,000	3,400	6,940,000	2,750
Japan	178,000	39	117,000	24
Malaysia	20,100	3	9,860	1
Mexico	4,590	2	2,990	2
Singapore	190,000	22	193,000	50
South Africa	65,700	108	66,500	55
Switzerland	530,000	551	584,000	492
Thailand	152,000	26	145,000	29
United Arab Emirates	1,390,000	250	749,000	198
United Kingdom	499,000	229	383,000	204
Other	331,000	134	1,710,000	534
Total	24,800,000	8,750	20,900,000	7,780
Grand total	34,000,000	14,700	25,200,000	9,940

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF DIAMOND, BY KIND, WEIGHT, AND COUNTRY[1]

	2008		2009	
Kind, range, and country of origin	Quantity (carats)	Value[2] (millions)	Quantity (carats)	Value[2] (millions)
Rough or uncut, natural:[3]				
Angola	62,300	$34	359,000	$48
Australia	1,620	1	17,700	2
Botswana	108,000	147	88,100	35
Brazil	760	1	443	(4)
Canada	19,900	31	27,300	32
Congo (Kinshasa)	37,100	138	11,600	7
Ghana	1,400	2	250	(4)
Guyana	6,590	1	212	(4)
India	120,000	4	32,700	1
Namibia	6,550	5	10,000	6
Russia	90,200	19	16,500	3
South Africa	119,000	296	104,000	112
Other	153,000	73 [r]	32,000	43
Total	725,000	752	700,000	289
Cut but unset, not more than 0.5 carat:				
Belgium	295,000	118	344,000	127
Canada	10,900	13	7,910	7
China	110,000	34	25,800	18
Dominican Republic	65,800	20	38,200	10
Hong Kong	157,000	25	239,000	24
India	6,520,000	1,430	5,760,000	1,150
Israel	512,000	267	400,000	198
Mauritius	8,410	14	6,920	15
Mexico	52,600	10	65,900	10
South Africa	12,400	4	1,780	10
Thailand	72,200	21	60,800	17
United Arab Emirates	69,400	18	153,000	30
Other	72,400	25	57,400	38
Total	7,960,000	2,000	7,160,000	1,650
Cut but unset, more than 0.5 carat:				
Belgium	929,000	3,130	640,000	2,130
Canada	22,800	78	20,200	60
Hong Kong	76,800	361	26,800	76
India	1,440,000	2,450	1,110,000	1,930
Israel	2,210,000	9,120	1,670,000	5,350
Mexico	389	(4)	1,810	3
Russia	57,600	178	57,800	137
South Africa	55,200	759	34,700	533
Switzerland	19,200	383	23,500	238
Thailand	11,700	22	3,980	9
United Arab Emirates	33,100	124	33,900	60
Other	101,000	400	53,200	256
Total	4,960,000	17,000	3,670,000	10,800

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

[3] Includes some natural advanced diamond.

[4] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF GEMSTONES, OTHER THAN DIAMOND, BY KIND AND COUNTRY[1]

Kind and country	2008		2009	
	Quantity (carats)	Value[2] (millions)	Quantity (carats)	Value[2] (millions)
Emerald:				
Belgium	529	$2	1,980	$1
Brazil	106,000	6	500,000	7
Canada	2,830	(3)	434	(3)
China	2,210	(3)	4,150	(3)
Colombia	530,000	155	314,000	120
France	130,000	9	315	2
Germany	13,800	3	8,470	2
Hong Kong	877,000	10	334,000	23
India	1,800,000	29	2,410,000	18
Israel	162,000	25	181,000	20
Italy	4,240	2	2,380	1
Switzerland	23,900	24	7,980	8
Thailand	564,000	13	292,000	8
United Kingdom	1,050	2	356	1
Other	83,300	17	38,000	3
Total	4,300,000	297	4,090,000	214
Ruby:				
Belgium	9	(3)	10	(3)
China	7,360	1	2,100	(3)
Dominican Republic	994	(3)	--	--
France	1,210	1	37	(3)
Germany	12,400	1	8,370	(3)
Hong Kong	851,000	10	420,000	1
India	2,350,000	5	2,500,000	2
Israel	1,370	1	5,560	1
Italy	6,030	1	1,330	(3)
Kenya	(3)	(3)	16,700	(3)
Sri Lanka	7,260	1	2,020	1
Switzerland	10,600	11	933	3
Thailand	1,980,000	59	1,750,000	14
United Arab Emirates	1,760	1	64	2
Other	43,300	8	179,000	13
Total	5,280,000	100	4,880,000	37
Sapphire:				
Australia	1,550	(3)	2,340	(3)
Austria	124	(3)	472	(3)
Belgium	110	1	283	1
China	269,000	2	122,000	1
Dominican Republic	882	(3)	600	(3)
Germany	36,200	5	33,200	5
Hong Kong	972,000	9	610,000	13
India	1,150,000	12	2,140,000	6
Israel	28,800	4	9,780	1
Italy	2,340	2	15,000	1
Singapore	3,630	(3)	3,010	(3)
Sri Lanka	316,000	46	240,000	31
Switzerland	17,800	19	14,700	14
Thailand	2,900,000	75	1,730,000	48

See footnotes at end of table.

TABLE 8—Continued
U.S. IMPORTS FOR CONSUMPTION OF GEMSTONES, OTHER THAN DIAMOND, BY KIND AND COUNTRY[1]

	2008		2009	
Kind and country	Quantity (carats)	Value[2] (millions)	Quantity (carats)	Value[2] (millions)
Sapphire—Continued:				
United Arab Emirates	8,140	$5	2,530	$2
United Kingdom	1,100	4	504	1
Other	384,000	7	68,200	3
Total	6,090,000	191	4,990,000	127
Other:				
Rough, uncut:				
Australia	NA	3	NA	(3)
Brazil	NA	7	NA	(3)
Canada	NA	1	NA	1
China	NA	3	NA	1
Colombia	NA	1	NA	--
Czech Republic	NA	2	NA	2
Germany	NA	1	NA	1
India	NA	2	NA	1
Japan	NA	1	NA	1
Pakistan	NA	2	NA	(3)
Tanzania	NA	3	NA	(3)
Other	NA	16	NA	1
Total	NA	42	NA	8
Cut, set and unset:				
Australia	NA	15	NA	(3)
Austria	NA	4	NA	1
Brazil	NA	19	NA	(3)
Canada	NA	1	NA	(3)
China	NA	35	NA	8
France	NA	1	NA	(3)
Germany	NA	34	NA	11
Hong Kong	NA	32	NA	1
India	NA	74	NA	2
Israel	NA	8	NA	(3)
Italy	NA	1	NA	(3)
South Africa	NA	1	NA	--
Sri Lanka	NA	5	NA	(3)
Switzerland	NA	8	NA	1
Taiwan	NA	1	NA	(3)
Tanzania	NA	5	NA	1
Thailand	NA	58	NA	1
United Arab Emirates	NA	1	NA	(3)
United Kingdom	NA	1	NA	--
Other	NA	15	NA	3
Total	NA	319	NA	29

NA Not available. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9
VALUE OF U.S. IMPORTS OF LABORATORY-CREATED AND IMITATION GEMSTONES, BY COUNTRY[1, 2]

(Thousand dollars)

Country	2008	2009
Laboratory-created, cut but unset:		
Austria	2,330	1,430
Brazil	645	374
Canada	24	9
China	9,860	7,600
Czech Republic	55	42
France	298	284
Germany	12,700	11,100
Hong Kong	898	455
India	1,040	2,180
Italy	48	95
Japan	251	61
Korea, Republic of	207	46
Netherlands	5	5
South Africa	281	--
Sri Lanka	1,300	315
Switzerland	620	797
Taiwan	174	161
Thailand	1,330	975
United Arab Emirates	146	98
Other	1,960	3,390
Total	34,200	29,500
Imitation:[3]		
Austria	73,100	47,100
Brazil	25	2
China	21,000	13,300
Czech Republic	7,510	5,080
France	25	--
Germany	723	566
Hong Kong	46	358
India	83	302
Italy	148	123
Japan	58	--
Korea, Republic of	198	131
Russia	15	--
Taiwan	183	--
Thailand	10	39
United Kingdom	193	3
Other	275	208
Total	104,000	67,200

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

[3] Includes pearls.

Source: U.S. Census Bureau.

TABLE 10

U.S. IMPORTS FOR CONSUMPTION OF GEMSTONES[1]

(Thousand carats and thousand dollars)

Stones	2008		2009	
	Quantity	Value[2]	Quantity	Value[2]
Diamonds:				
Rough or uncut	725	$752,000	700	$289,000
Cut but unset	12,900	19,000,000	10,800	12,400,000
Emeralds, cut but unset	4,300	297,000	4,090	214,000
Coral and similar materials, unworked	5,320	12,200	4,430	10,500
Rubies and sapphires, cut but unset	11,400	291,000	9,880	164,000
Pearls:				
Natural	NA	14,100	NA	21,100
Cultured	NA	34,600	NA	26,900
Imitation	NA	4,190	NA	4,150
Other precious and semiprecious stones:				
Rough, uncut	1,620,000 r	20,900 r	1,080,000	15,000
Cut, set and unset	NA	285,000	NA	NA
Other	NA	9,200	NA	NA
Laboratory-created:				
Cut but unset	60,300	34,200	8,730	29,500
Other	NA	13,500	NA	8,240
Imitation gemstone[3]	NA	104,000	NA	67,200
Total	XX	20,900,000	XX	13,300,000

r Revised. NA Not available. XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

[3] Does not include pearls.

Source: U.S. Census Bureau.

TABLE 11

NATURAL DIAMOND: WORLD PRODUCTION, BY COUNTRY AND TYPE[1,2,3]

(Thousand carats)

Country and type[4]	2005	2006	2007	2008	2009
Gemstones:					
Angola	6,371	8,258	8,732	8,016 [r]	8,100
Australia	8,577	7,305	231	273	60 [e]
Botswana[e]	23,900	24,000	25,000	25,000	24,000
Brazil[e]	208	181	182	182 [r]	182 [5]
Canada	12,314	13,278	17,144	14,803	10,946
Central African Republic[e]	300	340	370	302 [r]	300
China[e]	100	100	100	100	100
Congo (Kinshasa)	7,000	5,800 [r]	5,700 [r]	4,200 [r]	3,600
Côte d'Ivoire[e]	210	210	210	210	210
Ghana	810	780	720 [e]	520 [e]	500 [e]
Guinea	440	380	815	2,500	2,400
Guyana	357	341	269	169 [r]	179
Lesotho	52	231	454	450 [e]	450 [e]
Namibia	1,902	2,400	2,266 [r]	2,435 [r]	2,300
Russia[e]	23,000	23,400	23,300	21,925 [5]	17,791 [5]
Sierra Leone	401 [r]	362 [r]	362 [r]	223 [r]	200 [e]
South Africa[e]	6,400	6,100	6,100	5,200	2,400
Tanzania[e]	185	230	239	202 [r]	150
Venezuela[e]	46	45	45	45	45
Zimbabwe[e]	160	160	100	100	100
Other[6]	109	70	65	105 [r]	126
Total	92,800	94,000 [r]	92,400 [r]	87,000	74,100
Industrial:					
Angola[e]	708	918	970	900	900
Australia	25,730	21,915	18,960	15,397 [r]	10,700
Botswana[e]	8,000	8,000	8,000	8,000	7,000
Brazil[e]	600	600	600	600	600
Central African Republic[e]	80	85	93	75 [r]	60
China[e]	960	965	970	1,000	1,000
Congo (Kinshasa)	28,200	23,100 [r]	22,600 [r]	16,700 [r]	14,400
Côte d'Ivoire[e]	90	90	90	90	90
Ghana[e]	200	190	180	130 [r]	120
Guinea	100	95	200	600	600 [e]
Russia[e]	15,000	15,000	15,000	15,000	15,000
Sierra Leone	267 [r]	241 [r]	241 [r]	149 [r]	100 [e]
South Africa[e]	9,400	9,100	9,100	7,700	3,100
Tanzania[e]	35	42	44	31 [r]	27
Venezuela[e]	69	70	70	70	70
Zimbabwe[e]	900	900 [r]	600 [r]	700 [r]	700
Other[7]	94	67	72	115 [r]	140
Total	90,400	81,400 [r]	77,800 [r]	67,300 [r]	54,600
Grand total	183,000	175,000 [r]	170,000 [r]	154,000 [r]	129,000

[e]Estimated. [r]Revised.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 19, 2010.

[3] In addition to the countries listed, Nigeria and the Republic of Korea produce natural diamond and synthetic diamond, respectively, but information is inadequate to formulate reliable estimates of output levels.

[4] Includes near-gem and cheap-gem qualities.

[5] Reported figure.

[6] Includes Cameroon, Congo (Brazzaville), Gabon (unspecified), India, Indonesia, Liberia, and Togo (unspecified).

[7] Includes Congo (Brazzaville), India, Indonesia, and Liberia.

GERMANIUM

By David E. Guberman

The domestic table was prepared by Robin C. Kaiser, statistical assistant.

In 2009, germanium-bearing concentrates were produced at two zinc mines in Alaska and Washington (placed on care-and-maintenance status in early 2009) owned by Teck Resources Ltd. (Vancouver, British Columbia, Canada). The germanium-bearing concentrates were exported to Canada for processing or directly to customers in Asia and Europe. Two refineries in New York and Oklahoma produced germanium dioxide, germanium metal, and germanium tetrachloride from manufacturers' scrap, post-consumer scrap, and processed imported germanium compounds.

Germanium is a hard, brittle semimetal that first was used about a half century ago as a semiconductor material in radar units and as the material for the first transistors. Today, it is used principally as a polymerization catalyst for polyethylene terephthalate (PET), a commercially important plastic; as a component of glass in telecommunications fiber optics; as a lens or window in infrared night-vision devices; and as a semiconductor and substrate in electronic circuitry and solar cells.

Legislation and Government Programs

As a strategic and critical material, germanium was included in the National Defense Stockpile (NDS) in 1984. Sales of germanium metal were significantly lower in 2009 compared with those in previous years. The Defense National Stockpile Center (DNSC) reported that germanium metal sales in 2009 were 68 kilograms (kg) compared with 102 kg in 2008. Germanium was last sold in February 2009 at an average price of $1,331 per kilogram. As of December 31, 2009, the total inventory of germanium metal held by the NDS was 16,365 kg valued at $16.3 million.

During fiscal year 2009 (October 1, 2008, through September 30, 2009), the DNSC sold 170 kg of germanium metal at an average value of $1,392 per kilogram. The Annual Materials Plan for fiscal year 2010 (October 1, 2009, through September 30, 2010) allowed for the sale of up to 8,000 kg of germanium metal (Defense National Stockpile Center, 2009a, b).

Production

The multiple stages of the germanium production process yield germanium compounds and metals that are associated with specific applications. Germanium is initially recovered from the leaching of zinc residues or coal ash and the subsequent precipitation of a germanium concentrate. All germanium concentrates are purified using similar techniques, regardless of the source of the concentrates. The concentrated germanium is chlorinated and distilled to form the first usable product, germanium tetrachloride, a colorless liquid that is primarily used as a reagent in fiber-optic cable production. Germanium tetrachloride can be hydrolyzed and dried to produce germanium dioxide, another commonly used compound. Germanium dioxide appears as a white powder and is used to manufacture certain types of optical lenses and as a catalyst in the production of PET resin. Germanium dioxide can be reduced with hydrogen to produce a germanium metal powder, which is subsequently melted and cast into first-reduction bars. The germanium bars are then zone-refined (a refining process that involves melting and cooling germanium bars to isolate and remove impurities and ultimately yield extremely pure germanium) to produce electronic-grade germanium metal. Zone-refined germanium metal can then be grown into crystals and sliced for use as semiconductors or recast into forms suitable for lenses or window blanks in infrared optical devices.

In 2009, germanium was not recovered from zinc concentrates or coal in the United States. Domestic refinery production of germanium was estimated by the U.S. Geological Survey (USGS) based on data provided by North American producers. The USGS estimated that U.S. refinery production of germanium from imported primary material, germanium compounds, and new scrap was 4,600 kg in 2009.

Teck Alaska Inc. (a wholly owned subsidiary of Teck Resources) produced germanium-containing zinc concentrates at its Red Dog zinc-lead open pit mine in Alaska. Approximately 25% of the zinc concentrate produced at Red Dog was sent to Teck Resources' metallurgical complex in Trail, British Columbia, Canada. Residues from zinc concentrates were treated in roasters or pressure-leach facilities and purified to produce germanium dioxide and other byproduct metals. Teck Resources reported that zinc and lead concentrate production at Red Dog in 2009 was greater than that of 2008 owing to increased mill operating rates and online time resulting from a number of performance improvement initiatives.

In February, Teck Resources temporarily placed its underground Pend Oreille zinc-lead mine in northeastern Washington on care-and-maintenance status owing to reduced metal demand and the decline in zinc prices. Teck Resources indicated that, during the unspecified-duration closure at Pend Oreille, the company would continue to produce germanium and other byproduct metals at Trail from an existing residue stockpile at Pend Oreille. In 2009, Teck Resources produced 4,800 metric tons (t) of zinc concentrate at Pend Oreille compared with 35,000 t of zinc concentrate in 2008 (Teck Resources Ltd., 2010, p. 44–45).

In 2009, Umicore Optical Materials USA Inc. (a subsidiary of Umicore s.a., Brussels, Belgium) continued production of germanium metal and compounds at its plant in Quapaw, OK, and remained the leading domestic producer of germanium and germanium-base materials. Umicore produced germanium from fly ash, germanium concentrates, scrap generated internally or by the fiber-optics industry, and imported germanium compounds. The Quapaw facility refined the raw material into germanium tetrachloride, germanium metal, and proprietary [chalcogenide glass (GASIR®)] lenses, which were designed for large-scale commercial and military infrared optical systems. In 2009, construction work continued on a new germanium substrate plant in Quapaw that was expected to nearly double Umicore's global wafer production capacity to about 1 million substrates per year. The construction of the plant began in mid-October 2008 and was completed by yearend 2009. Umicore planned to start qualifying germanium substrates manufactured at the plant with customers during the first half of 2010. The company stated that the production capacity was added in anticipation of rapid growth in the terrestrial concentrator solar (or photovoltaic) cell market during the next 12 years (Umicore s.a., 2010b, p. 14).

Germanium Corp. of America (a subsidiary of Indium Corp. of America, Clinton, NY) produced germanium products, including germanium dioxide, germanium metal, and germanium tetrachloride at its facility in Utica, NY.

In January, Strategic Resource Acquisition Corp. (SRA) (Toronto, Ontario, Canada), owner of the Middle Tennessee zinc mining complex near Gordonsville, TN, filed for bankruptcy under Chapter 11 of the Federal Bankruptcy Code in Nashville, TN. The company had depleted its available funding and listed assets of about $1 million against debts of $100 million. In 2007, SRA had announced plans to restart operations at the idled mining complex, which consisted of zinc mines in Cumberland, Elmwood, and Gordonsville, TN, and had anticipated that the mines would be able to produce significant amounts of byproduct germanium and gallium. In October 2008, the company placed the mines on care-and-maintenance status owing to the state of the credit market and declining zinc prices. In May 2009, Nyrstar N.V. (Balen, Belgium), a leading global zinc and lead producer, announced that it had acquired the mine complex from Mid-Tennessee Zinc Corp. for about $13.3 million. Nyrstar also owned the Clarksville, TN, smelter, which was originally built to treat concentrates from the Middle Tennessee zinc mining complex, and the mine complex would be an important source of concentrate for the Clarksville zinc smelter. Nyrstar kept the mines on care-and-maintenance status for the remainder of 2009 but planned to commence production at the mine complex by yearend 2010. Once the mines were operational, the company stated that it intended to capture the value contained in the germanium- and gallium-rich zinc concentrates (Metal-Pages, 2009c; Nyrstar N.V., 2009).

In 2009, Australian exploration company PacMag Metals Ltd. reported that a resource drill program at the Church deposit in the company's Sentinel project in southwestern North Dakota had led to an initial inferred resource estimate of germanium, molybdenum, and uranium contained in lignite coal seams. The flat-lying mineralization of the coal seams in the region has been compared to lignite coal deposits found in China that produce germanium. The drilling program established that mineralization at the Church deposit was continuous in sufficient widths and lengths to accommodate mining. Metallurgical testing demonstrated successful leach recoveries of germanium, molybdenum, and uranium mineralization using acid or alkaline solutions. By yearend, the company was looking to secure a development partner that could help fund further assessment and possible future development of the Sentinel project (PacMag Metals Ltd., 2009, p. 2, 8–10).

Consumption

The USGS estimated that domestic consumption of germanium decreased to about 44,000 kg in 2009 from 54,500 kg in 2008 owing to the economic slowdown that affected sales of germanium for use in infrared optic, fiber-optic, and solar cell applications. Worldwide, the end-use pattern of germanium was estimated to be as follows: infrared optics, 30%; fiber optics, 20%; catalysts for PET, 20%; electronics and solar applications, 15%; and other uses (such as phosphors, metallurgy, and chemotherapy), 15%. The domestic end-use pattern, however, was different with infrared optics accounting for 50%; fiber optics, 30%; electronics and solar applications, 15%; and other uses (phosphors, metallurgy, and chemotherapy), 5%. Germanium was not used in PET catalysts in the United States.

Electronic Components.—Germanium substrate consumption for production of high-brightness light-emitting diodes (LEDs) used in such devices as automobile taillights, cameras, flashlights, mobile telephone display screens, televisions, and traffic signals increased in 2009 compared with that in the previous year. In electronics, silicon germanium (SiGe) components have replaced gallium arsenide in some high-tech products, such as components for cellular telephones. In high-speed wireless telecommunications devices, SiGe transistors can attain greater switching speeds and require less power than traditional, silicon-base components, increasing overall performance. SiGe-base microchips were also used in radar systems for automobiles to increase driving safety. Known as radar-on-chip-for-cars technology, these devices are capable of alerting drivers of impediments that are in the path of the vehicle in order to prevent potential accidents. A joint research cooperation project, supported by a financial grant from the German Federal Ministry of Education and Research, was launched in mid-2009 to advance this technology and make it available in all vehicle classes. Several automobile manufacturers and suppliers were working with semiconductor manufacturer Infineon Technologies AG (Neubiberg, Germany) on this project to develop new, cost-effective SiGe-chip-based automotive radar systems (Infineon Technologies AG, 2009).

Fiber Optics.—In the fiber-optics sector, germanium tetrachloride is converted to germanium dioxide and used as a dopant (a substance added in small amounts to the pure silica glass core to increase its refractive index, preventing signal loss while not absorbing light) within the core of optical fibers. Demand for fiber-optic cable in North America declined slightly in 2009 compared with that of 2008, reflective of an overall reduction in business activity owing to the global financial slowdown. Producers of germanium tetrachloride for fiber optics and fiber-optic cable producers indicated that sales volumes in 2009 were reduced from those in 2008, especially in North America and Europe. Fiber-optic cable manufacturers indicated that their customers were more cautious about making new investments in private networks and fiber-to-the-home (FTTH) technologies in 2009. This was not the case in China and other emerging Asian economies that continued to expand their telecommunications infrastructures in 2009. In 2009, the Fiber-to-the-Home Council estimated that 17.2 million homes in North America had FTTH available at their premises as of September 2009, an increase of about 13% from that in September 2008. The council reported that the growth rate of new fiber-optic runs had slowed considerably during the last half of 2009 owing to the deteriorating economic conditions (Corning Inc., 2010, p. 3, 30; Fiber-to-the-Home Council, 2010, p. 6–7).

The American Recovery and Reinvestment Act of 2009 included funding for a broadband initiative that led to the creation of a national broadband plan that could increase demand for fiber-optic cable in the future. The plan, created by the Federal Communications Commission (FCC), was intended to accelerate broadband deployment in underserved and rural areas and to strategic institutions that were likely to use broadband access to create jobs or provide public benefit. The term broadband referred specifically to high-speed internet access, such as that provided by fiber-optic cable, which is always on and faster than the traditional dialup access. The U.S. Congress directed the FCC to develop a plan that would ensure every American had "access to broadband capability." According to the initiative, widespread broadband infrastructure was considered a foundation for better quality of life, economic growth, global competiveness, and job creation. A long-term goal set forth in the plan specified the improvement of the existing broadband infrastructure in the United States to provide at least 100 million U.S. homes with access to affordable broadband connections by 2020. In addition to the national broadband plan, there were other broadband programs ongoing at the FCC, the National Telecommunications and Information Administration, the U.S. Department of Agriculture, and other Federal agencies (Federal Communications Commission, 2009, p. 12–15).

Infrared Systems.—Germanium was used in the manufacture of lenses and windows for infrared optical systems owing to its transparency to part of the infrared spectrum and to its high refractive index. Germanium is easily machinable, relatively strong, resistant to atmospheric oxidation, and able to withstand exposure to chemicals and moisture. The lenses and windows manufactured from germanium are often incorporated into thermal imaging systems that detect infrared radiation and convert it into an electronic signal, which is then processed and displayed on a video screen. Thermal imaging systems are different from other types of "low light" vision systems in that they are not adversely affected by the presence of light so they can be used day or night. It was estimated that about 60% of lower and midrange infrared-optical systems and 50% of all high-end devices used lenses made from germanium crystals.

In 2009, the sales value of the global infrared thermal imaging market was estimated to be about $6.6 billion. Military applications represented 80% of this market, with commercial applications accounting for the remaining 20%. All branches of the military continued to rely heavily on infrared devices for around-the-clock force protection and intelligence, surveillance, and reconnaissance (ISR) as well as target acquisition applications on multiple platforms. Air-, land-, and sea-based vehicles were routinely equipped with multiple infrared systems that allowed soldiers to perform a variety of combat-related functions in even the most adverse battlefield conditions. A typical ground transport vehicle might be outfitted with separate infrared imaging systems for driver and observer's vision enhancers, weapons sights, and roof-mounted imaging systems that perform long-range scans in search of improvised explosive devices. The military continued to invest in thermal weapon sight technology in 2009, which helped fuel domestic consumption of germanium optical products. In March, the U.S. Army Research, Development and Engineering Command Contacting Center at Aberdeen Proving Ground, MD, ordered more than 40,000 thermal weapons sights for small-arms, surveillance, and fire-control applications valued at more than $350 million from three manufacturers. This type of spending on thermal imaging devices was expected to continue in the near future to support troops currently engaged in ongoing military operations. In fiscal year 2010, the U.S. Department of Defense proposed to spend slightly less for procurement and research in military communications, electronics, intelligence, and telecommunications than it had in the previous year. The Army's technology procurement request for fiscal year 2010 included $235 million for purchasing common remotely operated weapons stations, $460 million for acquiring new night-vision devices, and $338 million for new thermal weapons sights. The U.S. Air Force requested $513 million to develop a new space-based infrared system (Keller, 2009).

Many of the thermal imaging manufacturers have made efforts to enter the commercial market to pursue growth opportunities that are expected in the near future. As the cost of infrared imaging technology has declined, demand has increased in markets such as airborne law enforcement, automotive night-vision, commercial security, firefighting, and recreational marine applications. Hand-held thermal imaging systems that can detect and measure small temperature differences were used for a variety of commercial and industrial applications, such as predictive and preventive maintenance. A leading thermal imaging device manufacturer reported that its revenue from commercial vision systems has grown at a compound annual rate of 25% since 2005 (FLIR Systems, Inc., 2010, p. 1).

Polymerization Catalysts.—Outside the United States, estimates indicated that germanium dioxide used as a catalyst for PET production has declined since 2007. Japan continued to be the leading consumer of germanium for this application. Demand for germanium dioxide used in PET was estimated to be about 20 t in 2009, down from about 30 t in 2008. An increase in recycling rates of PET-based products and an increase in PET substitution contributed to the decline in germanium dioxide consumption. Substitutes, including antimony trioxide and titanium, had the potential to replace the relatively expensive germanium as a catalyst in the future (Mikolajczak, 2010).

Solar Cells.—The use of germanium as a substrate in the production of solar cells is segmented into two markets—space-based applications and terrestrial installations. Demand for satellites has increased steadily during the 2007 through 2009 period owing to demand for commercial, military, and scientific applications. It was estimated that about 400,000 germanium substrates were consumed each year for space-based applications, and the majority of all satellites were powered by germanium-base solar cells (Umicore s.a., 2010a, p. 52). Germanium substrates were smaller in size and weight, more efficient at converting light into energy, and provided greater power output than the most common alternative substrate, silicon. Germanium substrates constitute the building blocks of multilayer (often referred to as multijunction) solar cells. Ultrathin layer combinations of materials, such as gallium indium phosphide and gallium arsenide are "grown" on top of the germanium substrate, each capturing a specific part of the solar spectrum and converting it into electricity. The solar energy conversion efficiency of these multijunction cells was typically greater than 25%. Currently, triple-junction cells are most common, but technological advancements have allowed for multijunction cells to combine more layers and junctions onto one cell, increasing performance capabilities. In 2009, Emcore Corp. (Albuquerque, NM), a manufacturer of compound semiconductor-based components and subsystems for the fiber-optic and solar power markets, was in the final stages of qualifying a next-generation, high-efficiency multijunction solar cell for satellites that had an average energy conversion efficiency of 30%. Another leading solar cell producer, Spectrolab Inc. (a subsidiary of The Boeing Co.) planned to produce germanium-substrate-based multijunction cells with conversion efficiencies greater than 33% in 2009. In comparison, the conversion efficiency of a standard silicon solar cell ranged from 13% to 15%. Umicore, a leading producer of germanium substrates, reported that sales volumes of germanium substrates in 2009 were slightly lower than those in 2008, reflective of a decline in orders from solar panel manufacturers owing to the global economic slowdown.

While satellites have traditionally used energy generated by solar panels to operate onboard systems and transmit data to Earth, there are other potential uses for the energy created by the high-efficiency solar cells. The use of solar energy, collected by space-based, high-efficiency multijunction cells, as a source of power for spacecraft was being developed. In 2009, an industry team led by Boeing received a contract from the Defense Advanced Research Projects Agency to design a new ultralightweight high-power generation system (HPGS) capable of generating up to 175 kilowatts of power (more than currently available to the International Space Station) for spacecraft. The team, comprising several leading satellite and solar cell manufacturers (including Emcore and Spectrolab), using high-efficiency, germanium-based, multijunction solar cells and sun tracking systems, developed a preliminary system that was one-half the weight and one-sixth the size of an existing orbital solar power system. Eventually, an HPGS was expected be able to provide power for a new generation of compact spacecraft that self-deploy from a low-Earth orbit and then reach a final orbit using electric propulsion systems to perform communications, satellite transfer and servicing, and space radar missions. A power system like this could be a cost-effective means for spacecraft to travel to the outer solar system without the need for radioisotope power (Umicore s.a., 2008, p. 14; The Boeing Co., 2009; Emcore Corp., 2010, p. 9).

Several manufacturers of germanium substrates, multijunction solar cells, and solar systems have focused capital investment and research efforts on the emerging terrestrial solar market. In 2009, Umicore completed construction of a new germanium substrate manufacturing facility in Quapaw in anticipation of increased future demand for terrestrial-based solar applications. While there is fairly widespread agreement that global demand for solar power generation and other sources of renewable energy will continue to increase during the next several decades, multiple solar cell technologies will compete for a portion of the solar power market. The multijunction solar cells that use germanium substrates and germanium layers are typically more expensive to manufacture than other technologies, such as cadmium telluride, crystalline silicon, or copper indium gallium diselenide thin-film cells, but are considerably more efficient at converting solar energy into electricity so fewer cells are required in a panel to produce equivalent amounts of power. To obtain the most energy possible from each multijunction cell in a solar panel, concentrator photovoltaic (CPV) technology is used. A concentrator system uses optics (mirrors or lenses) to focus high concentrations of direct sunlight onto the solar cells. The lenses or mirrors concentrate sunlight hundreds of times before it reaches the solar cell, making each cell more efficient. Concentrating panels must receive direct sunlight to operate so CPV installations are limited to geographic regions that receive proper levels of sunlight. CPV systems typically require tracking systems that allow the solar panels to follow the Sun's path during the day. CPV systems are marketed to the large-scale power generation industry and not considered a feasible solar power option for private homeowners.

As of 2009, CPV installations in China, Europe, and North America were generating about 24.5 megawatts (MW) of electrical power. By yearend 2009, new CPV projects under development in the United States were expected to produce about 17 MW of additional electrical power. It was estimated that, in current CPV installations, 1 MW of solar power generation required about 10 kg of germanium contained in 1,500 substrates. Multijunction solar cells have continued to become a viable option for use in large-scale concentrated solar power projects because their energy conversion efficiencies have been increasing at a rate of about 1% per year during the past decade. In August, Spectrolab announced that it had set a new world record for terrestrial concentrator solar efficiency with a new cell that converted 41.6% of concentrated sunlight into electricity. The Federal Government has also been actively involved in advancing solar energy technologies, including CPV systems. In October, the U.S. Department of Energy (DOE) announced that up to $87 million in funding would be made available to support the development of new solar technologies, including funding for 15 projects at DOE laboratories to improve devices, processes, and technologies for the concentrating solar power industry (Spectrolab Inc., 2009; U.S. Department of Energy, 2009; Umicore s.a, 2010c, p. 5).

Prices

The downturn in the global economy that began during the second half of 2008 continued in 2009, and the market price of germanium declined throughout the year owing to weakened global demand. Free market prices for germanium dioxide in 2009, published by Metal-Pages, began the year at about $920 per kilogram and declined by 37% to $580 per kilogram by yearend. The free market prices for germanium metal began the year at $1,425 per kilogram and declined by 34% to $940 per kilogram by yearend 2009.

Based on DNSC reports, the unit price of zone-refined germanium metal in inventory that was authorized for disposal as of December 2009 was $998 per kilogram.

Foreign Trade

According to the U.S. Census Bureau, imports for consumption of germanium metal (wrought, unwrought, and powder) decreased by 27% to 29,400 kg in 2009 from 40,200 kg in 2008. Decreased imports from Belgium accounted for the majority of the overall change. China, Russia, Belgium, and Germany, in descending order of quantity, accounted for 95% of imports into the United States in 2009 (table 1). The estimated germanium content of the germanium dioxide imported in 2009 was about 30,800 kg compared with 27,400 kg in 2008. Canada accounted for 53% of total germanium dioxide imports; Belgium, 29%; and Germany, 15%.

Domestic exports of germanium metal and articles thereof, including waste and scrap, were 21,200 kg in 2009 according to the U.S. Census Bureau. Belgium and Canada accounted for about 90% of germanium exported from the United States in 2009. The estimated germanium content of germanium dioxide exported from the United States in 2009 was less than 100 kg.

World Review

In 2009, the world's total supply of germanium was estimated to be between 100 and 120 t. This comprised germanium recovered from zinc concentrates or fly ash from coal and recycled material. The recycling level remained about the same as that in 2008 and supplied about 30% of the world's total supply of germanium. Owing to the value of refined germanium, new scrap generated during the manufacture of fiber-optic cables, infrared optics, and substrates is typically reclaimed and fed back into the production process. Recycling of germanium recovered from used materials, such as fiber-optic window blanks in decommissioned military vehicles or fiber-optic cables, has increased during the last decade. Worldwide, primary germanium was recovered from copper or zinc residues or from coal in Canada (concentrates shipped from the United States), China (multiple sources), Finland [concentrates from Congo (Kinshasa)], and Russia (lignite coal from Sakhalin). The vast majority of germanium production was concentrated in Canada and China.

Many germanium-related projects that were in exploratory or early development stages in 2008 when germanium prices were at elevated levels were halted or delayed in 2009 when prices declined. Some germanium producers reduced production in early 2009 to avoid stockpiling material that became more difficult to sell in a surplus market. As a byproduct metal, the supply of germanium was heavily reliant on zinc production, which declined on a global basis in 2009 owing to price declines and global economic conditions.

European Union.—In mid-2009, the European Union (EU) supported plans to ensure that industries get better access to critical raw materials as competition for these materials becomes greater. EU industries, particularly aerospace, high-tech, and telecommunications industries, were facing increased competition for natural resources from emerging economies, such as China and India. The European Commission (EC) proposed a strategy that included plans to ensure global access to critical raw materials, improve conditions for raw material extraction in Europe, and to reduce consumption of foreign raw materials by increasing resource efficiency and recycling rates in the EU. The EC planned to finalize a list of raw materials determined to be critical by yearend 2009, but the process extended into 2010. A preliminary list that was based partially on the results of a French study was presented in June, and it indicated that germanium was among a group of metals, the supply of which was considered to be a short- to medium-term supply risk. It was unclear what steps the EU would take upon completion of the critical materials list, but stockpiling some materials was a possibility (Wallop, 2009).

Belgium.—Umicore produced germanium metal, germanium tetrachloride for fiber optics, germanium substrates, and germanium optical products at its refining and recycling plant in Olen. The company also operated an electro-optic materials research and design facility in Olen. Umicore's substrate manufacturing facility had the capacity to produce about 600,000 germanium substrates (100 millimeters in diameter) per year. In 2009, Umicore's Advanced Materials Division reported that sales volumes of germanium substrates for space and terrestrial applications and of germanium tetrachloride for fiber optics decreased from those of the previous year. Conversely, sales volumes of germanium materials for infrared optical products and LEDs increased in 2009 from those in 2008 (Umicore s.a., 2010b, p. 22).

Canada.—The metallurgical complex operated by Teck Resources in Trail consisted of six major metallurgical plants, one fertilizer plant, and two specialty metal plants that produced byproduct metals, including germanium and indium. Teck has historically been one of the leading germanium producers in the world. Teck did not disclose germanium production information to the public for 2009. The last time that the company had made germanium production information available was for 2007, when Teck produced about 40,000 kg of germanium dioxide at Trail. Germanium was produced as a byproduct of the leaching of zinc concentrates, and in 2009, Teck's production of refined zinc from concentrates at Trail declined by 11% to 240,000 t of refined zinc from 270,000 t of refined zinc produced in 2008. Teck had curtailed zinc production at Trail from November 2008 to September 2009 in response to deteriorating market conditions. It was not known what effect, if any, this reduction in zinc production had on the level of germanium production in 2009. Based on trade data published by the Canadian Government, Canada exported about 40,100 kg of germanium contained in germanium dioxide in 2009 compared with 48,100 kg in 2008. About 89% of the germanium dioxide was exported to Japan and the United States in 2009 (Statistics Canada, 2010; Teck Resources Ltd., 2010, p. 10, 44).

China.—China continued to be the leading global producer of germanium metal and germanium compounds. The germanium reserve base in China was estimated to be about 3,500 t and was spread throughout 11 Provinces and regions. In 2009, five to six producers accounted for the majority of the estimated 85 to 100 t of germanium metal and germanium compounds produced in China. About 44% of this production was in the form of germanium metal, 42% was germanium dioxide (metal content), and 14% was in the form of other compounds. Germanium-bearing coal ash and zinc ore were the sources for the Chinese germanium production. The germanium market slowed during the second half of 2008, and this slowdown continued in 2009. From June 2008 to June 2009, the market price of germanium metal in China declined by more than 33% to less than $1,000 per kilogram from $1,500 per kilogram. Domestic producers had difficulty selling germanium compounds and metal even at the lower price levels, and some decided to stockpile germanium or curtail production until prices increased again. Producers were not willing to sell germanium metal at prices that approached their production costs, and consumers of the material tried to buy smaller quantities than usual in anticipation of further price declines. Partially in response to slumping prices and market conditions, Yunnan Province announced that it was stockpiling about 1 million metric tons of nonferrous metals in 2009, including 8 t of germanium metal, in an attempt to stabilize the domestic markets for these metals and to ensure that production was not adversely affected (Metal-Pages, 2009a, b, d).

Xilingol Mengdong Germanium Technology Co., established in 2008, was involved in the development of a new manufacturing facility in Xilingol, Mongolia, that would produce primary germanium and germanium compounds. Mengdong Germanium's parent company owned the mining rights to significant lignite coal resources containing an estimated 3,230 t of recoverable germanium metal. The company planned to use a proprietary technology to extract the germanium from the coal that it recovered through open pit mining. When completed, the new facility was expected to have the capacity to produce 60 metric tons per year (t/yr) of germanium tetrachloride, 20 t/yr of germanium metal, and 10 t/yr of germanium dioxide. The company commenced small-scale production at the facility in the fourth quarter of 2009 and anticipated that the plant would be fully operational by yearend 2010 (Asian Metal Ltd., 2009).

China's consumption of germanium-base products has increased in recent years as the economy has grown and become more developed. Chinese demand for fiber optics, infrared thermal imaging systems, and germanium substrates for solar cells has increased. The growth can be attributed to demand from the military, scientific, and telecommunications industries for these applications. In 2009, demand for germanium in thermal imaging devices was estimated to be about 10 t compared with 8 t in 2008. Demand for fiber-optic cable in Asia, driven primarily by China and India, increased by about 46% in 2009 compared with that of 2008. Chinese production of germanium substrates for satellites was estimated to be 1.4 million substrates in 2009 (of which China consumed 200,000), an increase of about 17% from that in 2008. While most of the germanium substrates produced in China have been exported to other countries for use in the manufacture and assembly of solar cells, several companies were working on plans to begin manufacturing the solar cells domestically (Maozhong, 2010; Qin, 2010).

Mexico.—In February, War Eagle Mining Co. Inc. (Vancouver) announced that it had suspended exploration drilling at the idled Tres Marias zinc and germanium mine in Chihuahua. In 2007, when germanium and zinc prices were elevated, the company began exploring the possibility of restarting the mine and producing germanium-rich zinc concentrates. However, the company decided to suspend all activities in early 2009 to conserve capital and minimize expenditures in light of the state of global financial markets and declining zinc prices. The company planned to focus its efforts on projects that involved the recovery of germanium from fly ash and similar materials owing to lower cost expectations associated with those germanium production processes when compared with mining costs (War Eagle Mining Co. Inc., 2009).

Namibia.—Emerging Metals Ltd. (Douglas, United Kingdom), a mineral exploration company that was incorporated in the British Virgin Islands, was investigating the possibility of extracting germanium from the slag stockpiles near the town of Tsumeb. In January 2008, Emerging Metals had purchased an option to acquire processing and ownership rights to the Tsumeb slag stockpiles from Ongopolo Mining Ltd. [a wholly owned subsidiary of Weatherly International plc (London, United Kingdom)]. In 2009, the company continued studies and test work on the slag stockpiles to determine the viability of extracting the contained metals, principally germanium but also gallium and zinc. In response to the weakened market conditions for these metals in 2009, the company emphasized its need to minimize costs associated with evaluating and test work and was reassessing the scope, timing, and feasibility of the project (Emerging Metals Ltd., 2009, p. 2).

Outlook

Global germanium consumption was likely to increase slightly during the next several years owing to the growth that is expected in the major end-use sectors. Germanium-base optical blanks and windows that are incorporated in infrared devices were expected to continue to be heavily used by military and law enforcement agencies. New applications for these products in commercial and industrial markets also were expected to become more prevalent. Global demand for fiber-optic cable, led by the emerging Asian economies, had been forecast to increase at a compound annual growth rate of 8% through 2012. Global support for the increased use of solar energy during the next several years is expected to increase demand for germanium substrates that are used to manufacture high-efficiency multijunction solar cells. As energy conversion efficiencies continue to improve, terrestrial-based solar systems will be more feasible options for large-scale power generation. Growth in the terrestrial-based solar cell market could significantly boost annual germanium substrate consumption (Mikolajczak, 2010).

Germanium substrates used in thermophotovoltaic (TPV) cells that convert heat radiation (instead of sunlight) generated from sources such as furnaces or water boilers into electricity could be a future growth area. Most TPV cells were used almost exclusively for military applications, but this technology could be applied in industrial or residential settings. In an industrial setting, for example, TPV cells could generate electricity from the heat created during the production of materials such as glass or steel.

On the supply side, reductions in global zinc production in 2009 could reduce the quantities of byproduct metals, such as germanium, that are available in the near future. The decline in germanium production in 2009 owing to the zinc market decline could tighten global germanium supply from 2010 through 2012, leading to price increases; therefore, producers might find market conditions more favorable to develop new sources of germanium. The redevelopment of existing zinc mines in Tennessee could be a new domestic source of germanium during the 2010 through 2012 period. Several germanium recovery projects in China that were in late stages of development or early production also could bring more germanium to the market if demand continues to increase. In addition to primary germanium production, the availability of recycled germanium recovered from end-of-life products, such as fiber optics, military vehicles, and solar cells, was expected to increase during the next couple of decades as these aging products are taken out of service.

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TABLE 1

U.S. IMPORTS FOR CONSUMPTION OF GERMANIUM METAL, BY COUNTRY[1, 2]

	2008		2009	
Country	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Belgium	18,300	$9,830,000	5,490	$5,960,000
Canada	173	175,000	796	425,000
China	14,000	17,300,000	14,000	14,800,000
France	22	36,700	124	91,100
Germany	1,890	3,830,000	2,360	4,290,000
Hong Kong	503	380,000	363	380,000
Japan	1	5,000	203	185,000
Russia	5,280	7,770,000	5,980	8,900,000
United Kingdom	62	257,000	53	33,800
Other	12 r	27,700 r	38	4,030,000
Total	40,200	39,600,000	29,400	39,100,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Data include wrought, unwrought, and powder, but exclude germanium dioxide.

Source: U.S. Census Bureau.

GOLD

By Micheal W. George

Domestic survey data and tables were prepared by Wanda G. Wooten, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2009, domestic mine production of gold decreased to 223,000 kilograms (kg), 4% less than that in 2008 (tables 1, 2). This marks the ninth year in a row that production has dropped, and production was 39% lower than the historical high of 366,000 kg in 1998. In 2009, the value of domestic production increased to $7 billion, up by 7% compared with that in 2008 because of the increase in the price of gold. It was the eighth straight year that the value had increased. Production from the major mines in Nevada was lower as a result of mining lower grade ore, the closure of two mines, and companies concentrating on mine development instead of gold production. Many mine projects and expansions planned within the past 5 years have been slow to develop; however, some of these projects were expected to begin production in 2010. Three mines began or restarted production in 2009—Briggs Mine in California and Jerritt Canyon and North Lantern Mines in Nevada. However, three mines stopped production in 2009—Deep Post and Jerritt Canyon Mines in Nevada and Golden Sunlight Mine in Montana. Price increases have spurred exploration and development of new gold projects. However, since new mines can take more than 10 years to open, there was a lag in the replacement of older mines with the opening of new mines. There was less investment in new projects during the economic slowdown that started in 2008. Mines in Nevada accounted for almost 72% of domestic production in 2009. The remaining production came from mines in Alaska, Utah, Colorado, Washington, California, South Dakota, Montana, Arizona, Idaho, and New Mexico, in descending order of production. Gold was produced at lode mines, a few large placer mines in Alaska, and numerous small placer mines, mostly in Alaska and the Western States. In addition, domestic gold was produced as a byproduct of processing base metals, primarily copper. In the United States, 30 operations yielded 99% of the gold produced (table 3).

The 2009 domestic exploration budget decreased to $510 million, a 42% decrease compared with that in 2008. Much of the decrease was a result of reduced exploration in copper and gold targets in Alaska and gold targets in Nevada. The reasons for reduced exploration were the economic downturn and the lack of available credit to finance projects. The worldwide gold exploration budget fell by 28% compared with that in 2008 to $3.5 billion and represented 48% of the worldwide exploration budget for all minerals (Lowrey, 2009; Wilburn, 2010).

Commercial-grade refined gold was produced by about two dozen domestic companies. Of the several thousand companies and artisans, a few dozen companies dominated the fabrication of gold into commercial products. U.S. jewelry manufacturing was heavily concentrated in the New York, NY, and Providence, RI, areas, with other manufacturers in California, Florida, and Texas. In 2009, the estimated percentages for end use of gold were jewelry and arts, 69%; dental and medical, 9%; electrical and electronics, 9%; and other, 13%.

Trade in refined bullion comprised 40% of U.S. gold imports and 74% of exports; the United States was a net exporter of 154,000 kg of bullion in 2009 (table 4). The decrease in exports was caused by unusually high exports in 2008 caused by an increase in price and an increase in investments outside the United States. Canada and Mexico provided almost 52% and 21%, respectively, of the refined bullion imported, and the United Kingdom and Australia were the destinations for 78% and 9%, respectively, of the refined bullion exported (table 6).

Engelhard's daily price of gold was volatile and rose above the $1,200-per-troy-ounce level for the first time ever in December. The price began the year at $876.64 per troy ounce and fell to the year's lowest level of $812.03 per troy ounce on January 15. The price rose for the rest of the year and peaked at $1,215.21 per troy ounce on December 2 before dropping to $1,127.56 per troy ounce by yearend. The annual average price of $974.68 per troy ounce, 12% above the annual average gold price in 2008, was the highest annual average price ever.

Gold investment continued to be very high in 2009 because of the financial and economic crisis; such times are traditionally when investment in gold, which is considered to be a safe investment, increases. It was estimated that investors purchased 1,900 metric tons (t) of gold in 2009 and resulted in regional supply shortages for small bars and coins. In 2009, gold held in 17 gold exchange-traded funds (ETFs) and 2 physically backed Canadian funds increased by 617 t to 1,839 t. With physical shortage of small bars and coins, many investors bought gold though ETFs. Most of the increase was in the first 3 months of the year. Domestic gold holdings in ETFs increased by 43%, or 366 t, to 1,213 t, with the SPDR Gold Trust, which was traded on the New York [NY] Stock Exchange, accounting for 93% of domestic gold ETF holdings. Because gold ETFs are essentially paper gold products, each share representing a physical allotment of gold that is held in trust, they provide an easily accessible investment. Gold ETFs follow market gold prices, with a fee structure to cover administrative and storage costs (Klapwijk and others, 2010, p. 26).

The top 15 mining companies produced about one-half of 2009 world gold production. The top five producers, in descending order, were Barrick Gold Corp. (Toronto, Ontario, Canada), Newmont Mining Co. (Denver, CO), AngloGold Ashanti Ltd. (Johannesburg, South Africa), Gold Fields Ltd. (Johannesburg), and Freeport-McMoRan Copper & Gold Inc. (Phoenix, AZ), which accounted for almost one-third of world gold production (Klapwijk and others, 2010, p. 48).

In 2009, the gold mining industry reversed the recent trend of large number of mergers and acquisitions. AngloGold Ashanti and Randgold Resources Ltd. (London, United Kingdom) purchased a 90% interest in Moto Goldmines Ltd.'s (Subiaco, Western Australia, Australia) Moto project in Congo (Kinshasa). IAMGOLD Corp. (Toronto) bought Orezone Resources Inc. (Ottawa, Ontario, Canada) for the Essakane project in Burkina Faso. Newmont purchased the remaining 33.33% of Boddington Mine in Australia from AngloGold Ashanti. Teck Resources Ltd. (Vancouver, British Columbia, Canada) sold off several noncore gold assets to relieve some of its financial problems. The company sold 60% of the interest in the Agi Dagi and Kirazli gold project in Turkey to Alamos Gold Inc. (Toronto); 79% of the interest in the Morelos gold project in Mexico to Gleichen Resources Ltd. (Toronto); 40% of the interest in the Pogo Mine in Alaska to Sumitomo Metal Mining Co. Ltd. (Tokyo, Japan) and Sumitomo Co. (Tokyo); 50% of the interest in the Hemlo Mines to Barrick; and 60% of the interest in the Lobo-Marte gold project in Chile to Kinross Gold Corp. (Toronto). Eldorado Gold Corp. (Vancouver) acquired Sino Gold Mining Ltd. (Sydney, New South Wales, Australia), which had one mine and several projects in China (Klapwijk and others, 2010, p. 48).

Total world mine production of gold in 2009 was 7% higher than that of 2008. Mine production in China increased, and China continued to be the world's leading gold producer. Annual output in South Africa decreased for the ninth year in a row because of higher costs, lower grade ore, and labor issues. The leading producers among the more than 95 gold-mining nations, in descending order, were China, the United States, Australia, South Africa, and Russia (table 8).

An estimated 165,600 t of gold was mined historically through 2009, with 28,900 t held by central banks as official stocks, 29,600 t held privately as investment, 83,700 t held privately as jewelry, 19,800 t in other fabricated products, and the remaining 3,600 t was unaccounted for (Klapwijk and others, 2010, p. 58).

Production

Domestic lode mine production data for gold were compiled by the U.S. Geological Survey from two separate voluntary surveys of U.S. mining operations—one for monthly production of copper, gold, lead, silver, and zinc from lode mines and the other for lode mine production data surveyed annually. Individual company production and performance data listed in table 3 and cited elsewhere in this report were obtained from published sources, such as company annual reports.

Alaska.—The State's Division of Geology and Geophysical Surveys reported that gold output increased to 24,100 kg valued at $754 million in 2009 from 24,900 kg valued at $698 million in 2008, or a decrease in production of 3% and an increase in value of 8% (Szumigala and others, 2010, p. 11).

The Pogo Mine, 145 kilometers (km) southeast of Fairbanks, was completed in 2006. The mine was a joint venture between Sumitomo Metal Mining (51%), Teck (40%), and Sumitomo (9%) and was operated by Teck. On July 7, Teck sold its 40% share to the other partners for $245 million. Sumitomo Metal Mining Pogo LLC operated the mine and owned 85% of it, and Sumitomo owned the remaining 15%. The mine produced a total of 12,100 kg of gold in 2009, which was more than the projected production of 11,100 kg of gold. Pogo was one of three operations that provided gold for the medals used for the 2010 Winter Olympics in Vancouver; the other two operations were Hemlo Mine and Trail Smelter in Canada (Szumigala and others, 2010, p. 13).

Kinross' underground Fort Knox Mine, near Fairbanks, produced 8,190 kg of gold equivalent (which includes silver) in 2009, 20% less than production in 2008 because lower grade ore was mined. Construction of the Walter Creek heap-leach facility, which had begun in October 2007, was completed in November when the first gold was poured from the facility (Kinross Gold Corp., 2010, p. 4, 11, 39).

Hecla owned one of the leading silver mines in the country, the polymetallic Greens Creek Mine on Admiralty Island near Juneau. The ore from the underground mine was milled at the mine site, and the smelter produced gold and silver dore, lead, zinc, and bulk concentrates. In 2009, production was 2,090 kg, the same as in 2008 (Hecla Mining Co., 2010, p. 3, 11).

The Nixon Fork Mine, owned by Pacific North West Capital Corp. (Vancouver), started production in 2007; however, production was suspended in October 2008. The mine was placed on care-and-maintenance status because of dramatically lower grade ore than expected. In July 2009, Pacific North West entered into an option to sell the mine to Fire River Gold Corp. (Vancouver). Fire River Gold expected to have a new resource estimate for the project by fall 2010 and a decision on the mine's future by yearend 2010 (Szumigala and others, 2010, p. 8).

The number of Alaskan placer operations that produced gold decreased to 141 in 2009 from 195 in 2008. Estimated placer production in 2009, which was included in the data reported by the State, decreased slightly to 1,710 kg from 1,770 kg of gold in 2008. In 2009, recreational mining activities increased owing to higher gold prices; however, gold production was 9 kg compared with 13 kg in 2008 (Szumigala and others, 2010, p. 14).

On June 22, the U.S. Supreme Court reversed the decision of the U.S. Court of Appeals for the Ninth Circuit decision that had invalidated the permits for the tailings facilities for Coeur d'Alene Mines Corp.'s (Coeur d'Alene, ID) Kensington project. On August 14, the U.S. Army Corps of Engineers reactivated the permit that cleared the way to construct the tailings facilities. The company planned to commence production during the third quarter of 2010. The underground gold project, 72 km north-northwest of Juneau, had reported reserves of 46,000 kg of gold (Coeur d'Alene Mines Corp., 2010, p. 40–41).

NovaGold Resources Inc. (Vancouver) was developing three projects—Big Hurrah, Nome Gold, and Rock Creek—all near Nome on the Seward Peninsula. The most advanced was the Rock Creek Mine, which was designed to produce about 3,000 kilograms per year (kg/yr) of gold. The mine and mill began production in 2008 but operated only a short time before operations at the mine were suspended and the mine entered a period of care-and-maintenance status. This was because of unanticipated mechanical problems, failure to meet environmental requirements, and the global financial downturn (NovaGold Resources Inc., 2010, p. 7).

In 2009, 23 exploration projects had a budget of $1 million or more, and 28 additional projects had exploration budgets of $100,000 or more. Exploration expenditures were $169 million in 2009, 51% lower than in 2008. Many of the companies in Alaska were looking for gold or copper-gold deposits (Szumigala and others, 2010, p. 1–2).

Northern Dynasty Minerals Ltd. (Vancouver) and Anglo American were 50–50 partners in the Pebble copper-gold-molybdenum project in southwestern Alaska, which included the high-grade underground Pebble East Mine and the open pit Pebble West Mine. Based on its $70 million budget, the project remained the leading exploration project in Alaska. As of December 2008, the measured and indicated resources were 1,770 t of gold, 22 million metric tons (Mt) of copper, and 1.3 Mt of molybdenum (Northern Dynasty Minerals Ltd., 2009).

In 2009, a feasibility study was completed on Barrick and NovaGold's Donlin Creek joint venture in the historic Kuskokwim Gold Belt in southwestern Alaska. The project had a measured and indicated gold resource of 1,050 t, and the companies were scheduled to file permit applications by the end of 2011 (NovaGold Resources Inc., 2010, p. 6).

International Tower Hill Mines Ltd. (Vancouver) continued to explore its Livengood project in 2009. The indicated resource was 297 t at a grade of 0.85 gram per metric ton (g/t) gold for 252 t of gold. The inferred resource was 164 t at a grade of 0.84 g/t gold for 138 t of gold. The project, 110 km north of Fairbanks, was undergoing heap-leach and metallurgical studies, which had been planned to be completed by the end of 2010 (Preston, 2009).

Arizona.—In 2009, all gold mined in Arizona was recovered as a byproduct from copper mining and processing. American Bonanza Gold Corp. (Vancouver) completed a mining plan and started the National Environmental Policy Act process for its Copperstone underground gold project in La Paz County (American Bonanza Gold Corp., 2009).

California.—In 2009, gold production was from New Gold Inc.'s (Vancouver) Mesquite Mine and Atna Resources Ltd.'s (Golden, CO) Briggs Mine. Other operations produced gold as a secondary product in 2009, mainly from placer sand and gravel mines and from several small underground mines that produced primarily specimen gold products.

On June 1, Western Goldfields Inc. (Toronto) entered into an agreement to merge with New Gold. In 2009, the Mesquite Mine open pit in Imperial County, CA, 70 km northwest of Yuma, AZ, produced 4,670 kg of gold, 38% more than that produced in 2008. Production increases were caused by transition to the second year of production, increases in recovery rates on leach pads, and the placement of more ore on the leach pads. Production in 2010 was forecast to be between 4,510 and 4,820 kg of gold (reported as between 145,000 and 155,000 troy ounces), and the deposit reportedly had proven and probable reserves of 97,600 kg of gold (New Gold Inc., 2010).

In the fourth quarter of 2008, Atna restarted operations at the Briggs Mine, and in May 2009, the company poured its first bar of gold. In 2009, the mine produced 348 kg of gold. An updated technical report on the Briggs Mine estimated the proven and probable reserves to be 7,240 kg of gold (Atna Resources Ltd., 2010, p. 6–7).

Sutter Gold Mining Inc. (Lakewood, CO) announced on November 19 that it was on track to obtain the remaining permits and approvals during the next 18 to 24 months as it completes the designs, secures financing, and completes construction of the Sutter Gold underground mine, which included the historic Lincoln gold mine along California's Mother Lode belt. The indicated mineral resources were 6,940 kg of gold (Sutter Gold Mining Inc., 2009).

Emgold Mining Corp. (Vancouver) continued the permitting process to reopen the historic Idaho-Maryland Gold Mine. The estimated measured and indicated resources were 14,700 kg of gold (Emgold Mining Corp., 2009).

Colorado.—In 2009, Colorado remained the fourth ranked gold-producing State in the country. The Nation's 10th ranked gold mine, the Cresson Mine, owned by Cripple Creek & Victor Gold Mining Co. (CC&V) (a fully owned subsidiary of AngloGold) reported that its open pit operation produced 6,780 kg of gold in 2009, a 16% decrease from that in 2008 owing to the vertical height of the leach pads and the greater distance over which the leaching solution would have to flow. In 2009, CC&V started construction of a mine-life extension project that would add 4 years to the mine production (AngloGold Ashanti Ltd., 2010, p. 96–99).

The Front Range gold property, which included the Cash and Rex Mines, was a joint venture among Global Minerals, Ltd. (Vancouver) (50%) and several private owners (50%). The property merged a collection of former producing high-grade gold mines into one contiguous group. The property produced a small amount of concentrate that was transported by truck to a third party's smelter (Global Minerals, Ltd., 2010, p. 5–6).

LKA International Inc.'s (Gig Harbor, WA) Golden Wonder Mine in the San Juan Mountains stopped commercial gold production in the second quarter of 2006. The company continued to explore and produced 23 kg of gold in 2009 as a result of exploration activities (LKA International, Inc., 2010).

Idaho.—Idaho had limited gold production in 2009 from New Jersey Mining Co.'s (Kellogg, ID) Golden Chest Mine near Murray. New Jersey Mining also continued to develop and explore in Idaho. In addition to New Jersey Mining, other companies with projects with associated gold were in early development stages in 2009.

Montana.—The open pit polymetallic Montana Tunnels Mine near Jefferson City [a 50–50 joint venture between Elkhorn Goldfields LLC (Denver) and Apollo Gold Corp. (Greenwood Village, CO)] ceased mining operations in December 2008 because of low base-metal prices. The company had stockpiled ore and operated the mill until the end of April 2009 when the mine was placed on care-and-maintenance status. Apollo was seeking to sell the property to focus on its Black Fox Mine in Ontario, Canada, and Elkhorn was investigating opening a new pit to resume operations (Elkhorn Goldfields LLC, 2010).

Barrick's Golden Sunlight Mine produced 871 kg of gold in 2009. This was 83% less than that in 2008 because the mine entered an extended development phase and was not expected to produce gold again until 2011 (Barrick Gold Corp., 2010a, p. 56; 2010b).

Nevada.—Gold production decreased by 10% to 161,000 kg in 2009. However, Nevada kept its long-standing position as the Nation's leading gold-producing State. Because of this decrease, Nevada's rank in world gold production fell from fifth to sixth. In 2009, gold remained the most valuable mine product in Nevada, representing almost 88% of gross proceeds of mines.

The Nevada Division of Minerals reported 20 major gold-silver operations (Dobra, 2010).

In 2009, Barrick produced 78,000 kg of gold from its fully owned Bald Mountain, Cortez, Goldstrike, Ruby Hill, and Storm Mines; a 75% share of the Turquoise Ridge Mines (a joint venture with Newmont, 25%); 50% of Smoky Valley Common Operation (50% owned and operated by Kinross); and 33.33% of the Marigold Mine (67.67% owned and operated by Goldcorp). This was 9% less than the company's gold mine production from Nevada in 2008. Open pit and underground production from Goldstrike was 42,100 kg of gold, a 21% decrease compared with that in 2008. The decrease was attributed to the partial shutdown of the autoclaves in the second half of 2009. Production from Bald Mountain was 2,330 kg, 40% less than production in 2008 owing to unplanned permitting delays for the expansion plans. These permitting issues have been resolved, and higher production levels were expected within 3 years. These decreases were partially offset by increases at the Cortez and Storm Mines owing to increasing ownership shares compared with those in 2008. In the first quarter of 2008, Barrick had purchased the remaining 40% of the Cortez Mine, and in 2009, Barrick's share of gold production increased by 21% compared with its 2008 share of gold production. Similarly, Barrick purchased the remaining 40% of the Storm Mine in the third quarter of 2008, and in 2009, Barrick's share of gold production increased by 195% compared with its 2008 share of gold production. Another mine with increased production in 2009 was the Ruby Hill Mine, which produced 3,220 kg of gold or 6% more than that in 2008. Production of gold in 2009 from partially owned mines was 12,200 kg, 4% less than that of 2008. In 2009, Barrick's share of gold production from the Marigold Mine was 1,520 kg (a slight decrease compared with 2008 gold production), 6,500 kg from the Smoky Valley Common Operation (a decrease of 11%), and 4,140 kg from Turquoise Ridge (an increase of 7%). Barrick completed construction on the Cortez Hills Mine in Lander County. In December, the U.S. Court of Appeals for the Ninth Circuit in an opinion about the Bureau of Land Management's approval of the project ruled that the order of the U.S. District Court for the District of Nevada denying the injunctive relief and permitting construction of the project was affirmed in part and reversed in part. The appeals court agreed that certain claims against the project were unlikely to succeed; however, the court found that more environmental analysis was needed on three matters—mine dewatering mitigation plans, particulate emissions, and transportation and treatment of refractory ore (Barrick Gold Corp., 2010a, p. 17, 56; 2010b).

Newmont produced 62,400 kg or 39% of Nevada's gold production from eight open pits and six underground mines. The operations were in Eastern Nevada Operations (Carlin East, Deep Post, Gold Quarry, Leeville, North Lantern, and Pete Mines), the Lone Tree, Midas, Mule Canyon, Phoenix, Trenton Canyon, Twin Creeks, and the joint-venture Turquoise Ridge (25% share) Mines. In 2009, gold production from Newmont's Nevada operations decreased by 10% because of mining lower grade ore, lower leach placement, and completion of mining at Deep Post. The losses were partially offset by the startup of the North Lantern Mine. Newmont expected to sell less gold from its Nevada operations in 2010 primarily because of mining lower grade ore (Newmont Mining Corp., 2010, p. 22–23, 58, 61).

In 2009, Yukon-Nevada Gold Corp. (Vancouver) produced 304 kg of gold, 73% lower than in 2008, from its Jerritt Canyon Mine, which consisted of a milling facility and two underground mines, Smith and SSX. In the first quarter of 2009, the company submitted a new plan for mercury emission control in order to restart operations. On March 25, the company received permission to restart the milling operation, and gold production started on April 16. The company closed the roaster operations on May 30 owing to a delay in fabrication of key components of the emission control systems, and a stop order was once again issued by the Nevada Division of Environmental Protection (NDEP). Operations were restarted on October 20 after the company resolved all of the compliance concerns with the NDEP (Yukon-Nevada Gold Corp., 2010, p. 4–5).

Rio Tinto plc (London) owned the Denton-Rawhide Mine, which produced 602 kg of gold in 2009. Mine production had been stopped in 2003, but residual production from leach pads continued (Rio Tinto plc, 2010, p. 65).

In 2009, the Robinson copper mine near Nye [owned by Quadra Mining Ltd. (Vancouver)] produced 55,600 t of copper and 3,080 kg of gold. Production was lower than that in 2008 because of changes to the mine plan and a drop in ore grade (Quadra Mining Ltd., 2010, p. 7).

The Rochester Mine, owned by Coeur d'Alene Mines, produced 68,400 kg of silver and 395 kg of gold. In August 2007, the company had completed mining the existing reserves; however, gold and silver production were expected to continue from stockpiled ore and existing leach pads until 2014. The company planned to continue to explore in and around the Rochester Mine (Coeur d'Alene Mines Corp., 2010, p. 33–34).

In 2009, Great Basin Gold Ltd. (Vancouver) extracted 71,000 t of ore, resulting in 2,520 kg of gold equivalent, from trial mining activities at the underground Hollister Mine. In December 2008, the company had purchased the Esmeralda mill and completed refurbishment of the mill in August 2009 (Great Basin Gold Ltd., 2010, p. 32–47).

The trend in exploration in Nevada decreased to $110 million in 2009 from $158 million in 2008. In spite of the reduction in exploration expenditures, reported proven and probable gold reserves in 2009 in Nevada increased to 2,330 t from 2,180 t in 2008 (Dobra, 2010).

Several projects were in the feasibility stage in 2009. These included Atna's Reward project, International Minerals Corp.'s (Scottsdale, AZ) Goldfield project, Newmont's Emigrant project, Pacific Gold Corp.'s (Reno) Black Rock Canyon project, and Scorpio Gold Corp.'s (Vancouver) Mineral Ridge project.

New Mexico.—Gold production in New Mexico was a byproduct of copper production in Grant County at Freeport-McMoRan's Ivanhoe concentrator. In 2009, gold production was 14 kg (New Mexico Energy, Minerals and Natural Resources Department, 2010).

In 2009, one silver and gold project began development, and several polymetallic deposits were explored. Santa Fe Gold Corp. (Albuquerque) was nearing production at the Summit silver and gold mine and anticipated that production at the mine would start in the first quarter of 2010 (Santa Fe Gold Corp., 2009).

South Carolina.—Romarco Minerals Inc. (Vancouver) announced a new measured and indicated resource for its Haile Gold Mine Project in Lancaster County, 44.6 Mt of ore at an average grade of 1.51 g/t gold, containing 67,500 kg of gold. In December, the company decided to launch a new feasibility study (Romarco Minerals Inc., 2010, p. 2–4).

South Dakota.—In 2009, Wharf Resources Inc. (Lead) operated the Goldcorp-owned Wharf open pit gold mine near Lead, which produced about 2,110 kg of gold, 12% more than 2008 gold production. The increase was attributed to the improved leach pad management and plant improvements, which more than offset the drop in grade and lower ore processing (Goldcorp Inc., 2010, p. 31).

Utah.—Rio Tinto's Bingham Canyon Mine near Salt Lake City, which was operated by Kennecott Utah Copper Corp. (Magna) produced 18,100 kg of gold as a byproduct from its copper mining operation. Bingham Canyon remained the third-ranked gold producer and the leading gold-producing mine outside Nevada in 2009. Gold production increased by 37% compared with that in 2008 because of greater throughput of ore. The company has identified a new copper, molybdenum, and gold porphyry system beneath the open pit that is being mined. In 2009, Kennecott Utah also operated the nearby Barney's Canyon Mine, which had closed in the first quarter of 2002 but continued gold production from heap-leaching pads that produced 62 kg of gold. Several other small mines produced minor amounts of gold (Bon and Krahulec, 2010, p. 5; Rio Tinto plc, 2010, p. 40, 65).

Exploration for gold and silver decreased because of the economic downturn, which limited capital investment. Exploration was largely focused in the eastern Basin and Range Province of the western part of the State (Bon and Krahulec, 2009, p. 10).

Washington.—Kinross's underground Kettle River-Buckhorn Mine in the north-central part of the State marked its first full year of production. In 2009, the mine produced 5,400 kg of gold. The new mine fed the Kettle River Mill adjacent to the closed Kettle River Mine, which was about 76 km from the Kettle River-Buckhorn Mine. The project reportedly had an estimated 24,900 kg of gold reserves (Kinross Gold Corp., 2010, p. 5, 10, 41).

World Industry Structure

World gold mine production in 2009 was 7% higher than that in 2008, the first increase since 2005 (table 8). In 2009, gold production in 23 countries increased by more than 1 t from their production in 2008. Some of the larger increases in gold production were 65,600 kg in Indonesia; 35,000 kg in China; 18,700 kg in Russia; 13,500 kg in Colombia; 7,000 kg in Australia; 6,000 kg in Brazil; 5,870 kg in Burkina Faso; 5,500 kg in Ghana; 5,000 kg in Senegal; 5,000 kg in Uzbekistan; 4,950 kg in Argentina; 3,740 kg in Côte d'Ivoire; and 3,570 kg in Tanzania. These increases were partially offset by gold production decreases in several countries. In 2009, production of gold decreased by more than 1 t in nine countries. Some of the larger decreases in gold production in 2009 were 15,000 kg in South Africa; 10,000 kg in the United States; 5,380 kg in Mongolia; 2,000 kg in Papua New Guinea; and 1,860 kg in Guinea. In 2009, the 12 leading gold producing-countries—China, the United States, Australia, South Africa, Russia, Peru, Indonesia, Canada, Uzbekistan, Ghana, Papua New Guinea, and Brazil (in descending order) accounted for 76% of global production. The next 10 leading gold-producing countries accounted for another 15%, while the remaining 79 countries made up 9% of global gold production in 2009.

According to its annual review of world gold supply and demand, Gold Fields Mineral Services Ltd. (GFMS) calculated that the total global supply of gold in 2009 was 4,287 t compared with the revised 2008 total supply of 3,957 t. GFMS also reported decreases in official sector sales (82%), increases in mine production (7%), no net producer hedging, and no implied net disinvestment for sales of bars and coins by private investors. Old scrap production increased by 27% in 2009 compared with 2008 old scrap production to an alltime high because of the increase in gold price (Klapwijk and others, 2010, p. 7).

GFMS reported that total fabrication in 2009, including the use of scrap, was 2,417 t, 16% lower than that of 2008, the lowest since 1988. In 2008, gold jewelry fabrication was 1,760 t, 20% lower than that of 2007. The top six gold jewelry manufacturing countries, in descending order—India (474 t), China (340 t), Italy (123 t), Turkey (80 t), United States (63 t), and Saudi Arabia (54 t)—represented 64% of the world's jewelry production. In 2009, production in Turkey, Italy, the United States, and India decreased by 56%, 29%, 18%, and 9%, respectively, compared with jewelry production in 2008 owing to increased gold prices and the economic downturn. In contrast, gold jewelry fabrication in China rose by 8% in 2009. Coin fabrication was 229 t, an increase of 22% compared with that of 2008, the highest level in 23 years, and was the only end use that increased in 2009. The demand for safe-haven investments and the drop in reselling gold coins has led to increases in production, a gold coin shortage, and extended delivery times. In 2009, U.S. Mint sales of the American Eagle gold coins were 44,300 kg, which was 66% higher than sales in 2008, and sales of the American Buffalo coins were 6,220 kg (200,000 coins containing 1 troy ounce of gold each) an increase of only 17% compared with those in 2008. In 2009, Canada increased gold coin minting to 38,200 kg or an increase of 38% compared with minting in 2008, and Austria minted 24,900 kg, or 33% more during the same period. The amount of gold used in electronics declined by 16% to 246 t, which reflected the global economic downturn. Gold used in dentistry declined by 5% to 53 t in 2009 owing to an increase in nonmetallic substitutions. Gold used in other industrial and decorative applications decreased by 18%. Gold used in medals and for imitation coins (nonmonetary coins) decreased by 19% because of high and volatile gold prices (Klapwijk and others, 2010, p. 35–37, 80–106).

World Review

Argentina.—In 2009, production was 47,000 kg or 12% higher than production in 2008 because of new production from the Yamana Gold Inc.'s (Toronto) Gualcamayo Mine, which produced 4,460 kg of gold during the year. Gold production from Barrick's Veladero Mine also increased by 12% because of higher ore grades and increases in crushing capacity owing to the startup of the crusher circuit expansions (Barrick Gold Corp., 2010a, p. 57; Goldcorp Inc., 2010, p. 28–29).

In 2009, production from AngloGold's Cerro Vanguardia Mine was 6,470 kg of gold, a 25% increase compared with production in 2008. The increase was attributed to the resolution of some technical issues late in 2008 (AngloGold Ashanti Ltd., 2010, p. 102–103). These production increases were partially offset by production losses at Bajo de la Alumbrera Mine [owned by Xstrata plc (Zug, Switzerland) (50%), Goldcorp (37.5%), Yacimientos Mineros Agua de Dionisio (Catamarca) (20%), and Yamana (12.5%)] owing to mining lower grade ore (Yamana Gold Inc., 2010, p. 56–57).

Australia.—Australian gold production in 2009 increased by 3% compared with that in 2008. Production increases were from established operations combined with increases from mines that started in 2008. In 2009, two new mines started production—Newmont's Boddington Mine, which started production in November, and OZ Mineral Ltd.'s (Melbourne) Prominent Hill Copper Mine, which started production in April. A portion of the increase were partially offset by production losses at a number of established operations and a number of small-scale mines that closed because of lower ore grades (CPM Group, 2010, p. 90; Klapwijk and others, 2010, p. 44).

In 2009, Barrick had seven operations in Australia, from which Barrick's production was 44,400 kg of gold, 4% more than that in 2008. All operations except the Henty Mine, which Barrick sold to Bendigo Mining Ltd. (Melbourne) in July, saw increases in production compared with 2008 production. In 2009, the Yilgarn South operations produced 10,900 kg of gold, 8% more than production in 2008 because of better ore grades and an increase in mill throughput owing to an ore purchase agreement with a third party mining company. Other Barrick mines produced more gold in 2009 compared with 2008 production—Osborne, 30%; Cowal, 22%; Plutonic, 13%; and Kanowna, 6%. Production from Kalgoorlie, a joint venture with Newmont, increased by 14% in 2009 compared with production in 2008 owing to an increase in overall ore grade (Barrick Gold Corp., 2010a, p. 57–56; b).

In 2009, AngloGold's Sunrise Dam Gold Mine produced 12,500 kg of gold, a decrease of 8% compared with 2008 gold production. The mine consisted of an open pit and an underground mine, and in early 2008, the high-grade ore area had been mined out (AngloGold Ashanti Ltd., 2010, p. 91–92).

In 2009, Newcrest Mining Ltd. (Melbourne) operated four mines in Australia. The Cadia Hill Mine produced 7,120 kg of gold, a 43% decrease compared with 2008 production because of lower ore grade; the 100%-owned Telfer and the 70%-owned Cracow Mines produced 16% and 4%, respectively, more gold compared with gold produced in 2008. The Ridgeway Mine produced 25% less gold in 2009 than it did in 2008 owing to lower ore grade (Newcrest Mining Ltd, 2009a-c, 2010).

Newmont's Boddington Mine poured the first gold bar in September and established commercial production in November. The mine sold 4,100 t of copper and 3,210 kg of gold. In 2009, Newmont also owned the Jundee and Tanami operations as well as the Kalgoorlie joint-venture project with Barrick. The Jundee operation sold 12,800 kg of gold in 2009, 10% more than sales in 2008. The Tanami operation sold 9,050 kg of gold, 21% less than in 2008 owing to a decrease in ore processed in 2009 (Newmont Mining Corp., 2010, p. 25, 65–66).

In April, OZ Minerals first produced concentrates from its Prominent Hill copper mine. During 2009, the mine produced 96,300 t of copper and 2,350 kg of gold. The company estimated that annual production in 2010 to 2012 would average 100,000 to 110,000 t of copper and 2,500 to 2,800 kg of gold (OZ Minerals Ltd., 2010, p. 15).

Gold Fields produced gold from two mines in Australia—Agnew and St. Ives. In 2009, Agnew produced 5,830 kg of gold, 7% less than that produced in 2008. St. Ives produced 12,900 kg of gold in 2009, about the same as 2008 production (Gold Fields Ltd., 2010, p. 1–8).

In 2009, North Queensland Metals Ltd. (Fortitude Valley) produced 1,540 kg of gold from the Pajingo Mine, slightly less than that of 2008. North Queensland was the operator and owned a 60% share; the remainder was owned by Heemskirk Consolidated Ltd. (Melbourne) (North Queensland Metals Ltd., 2010). In 2009, New Gold's Peak Mines produced 2,900 kg of gold, a 7% decrease compared with 2008 production. The decrease was caused by a drop in ore grade (New Gold Inc., 2010).

Compared with partial-year production data, production at a number of mines increased during their first full year of production. In 2009, Avoca Resources Ltd. (West Perth) produced 5,700 kg of gold from its Higginsville Gold Mine (Avoca Resources Ltd., 2010). The Frogs Leg Mine [a joint venture between La Mancha Resources Inc. (Montreal, Quebec, Canada) (51%) and Dioro Exploration NL (Nedlands) (49%)] produced 2,810 kg of gold, and St Barbara Ltd.'s (Melbourne) Leonora Mine produced 3,300 kg during the same period. Focus Minerals Ltd. (Perth) produced 1,560 kg of gold in 2009 (Focus Minerals Ltd., 2010; La Mancha Resources Inc., 2010; St Barbara Ltd., 2010).

Azerbaijan.—In May, Anglo Asian Mining plc (London) poured its first gold at the Gedabek copper and gold project. In 2009, the mine produced 353 kg of gold and planned to produce 1,660 kg of gold in 2010 (Anglo Asian Mining plc, 2010, p. 2, 7).

Brazil.—In 2009, Brazilian gold production increased by 11% compared with that in 2008 owing to startup of an expansion project at Kinross's Paracatu Mine that increased production by 88% (Kinross Gold Corp., 2010, p. 43–44).

Production from the AngloGold Ashanti Mineração, the country's leading gold mining complex, was 10,200 kg of gold or 3% more than that in 2008. Ore was produced from the Cuiaba and Lamego underground mines, leached at the Córrego do Sitio heap-leach operations, and then processed at the Cuiaba and Queiroz plants. The increased production was attributed to the increased mining at the Cuiaba Mine in the second half of 2009 (AngloGold Ashanti Ltd., 2010, p. 105–107).

Yamana operated five mines that produced gold in 2009. Chapada produced 4,860 kg of gold, a 4% increase compared with 2008 production because of increased ore mining and processing. The Jacobina complex of underground mines in the State of Bahia produced 3,440 kg of gold, a 51% increase compared with production in 2008. The increase resulted from the completion of plant upgrades and the mining of higher grade ore. The Fazenda Brasileiro Mine, an underground mine in northeastern Brazil, produced 2,380 kg of gold, 15% lower than that in 2008. Two other mines owned by Yamana in Brazil—São Vicente and São Francisco—were part of an agreement to be sold to Aura Minerals Inc. (Vancouver) that was expected to be finalized in early 2010. On September 1, São Vicente began commercial production and produced 1,540 kg of gold in 2009. The São Francisco Mine produced 2,570 kg of gold, an 8% increase compared with 2008 production (Yamana Gold Inc., 2009, 2010, p. 53–60).

In 2009, Serra Grande (a joint venture equally owned by AngloGold and Kinross) produced 4,790 kg of gold, a 13% decrease compared with that in 2008. The Serra Grande in central Brazil consists of three underground mines (Mina III, Mina Nova, and Palmeiras) and an open pit mine (Mina III). Difficulties in mining quartz veins and lower ore grades were the main reasons for the decrease in production in 2009 (AngloGold Ashanti Ltd., 2010, p. 108–109).

Jaguar Mining Inc. (Concord, NH) operated two active mines that produced gold in 2009. The company produced 4,820 kg of gold, 34% more than 2008 production. The Turmalina Mine produced 2,550 kg of gold and the Paciencia Mine produced 2,070 kg of gold in 2009. Production increased because the Paciencia had its first full year of production in 2009 (Jaguar Mining Inc., 2010, p. 7–8).

Burkina Faso.—In 2009, gold production was 13,500 kg, a 77% increase compared with 2008 production. The increase was partially attributed to the first full year of production from SEMAFO Inc.'s (Saint-Laurent, Quebec, Canada) Mana Mine that produced 4,770 kg of gold in 2009, a 107% increase compared with 2008 production (SEMAFO Inc., 2010, p. 9).

High River Gold Mines Ltd. (Toronto) owned and operated the Taparko-Bouroum Mine that produced 3,100 kg of gold. This was 225% higher than 2008 production owing to resolution of technical problems that surfaced during mill startup (High River Gold Mines Ltd., 2010).

In June, Cluff Gold plc (London) fully commissioned its 78%-owned Kalsaka Mine, which produced 1,690 kg of gold (Cluff Gold plc, 2010, p. 10–11).

Canada.—Canada ranked eighth in world gold production, as its output increased slightly to 97,400 kg. Goldcorp operated three mines in Ontario—the Musselwhite, Porcupine, and Red Lake Mines. In 2009, the Red Lake Mine produced 19,400 kg of gold, a slight decrease compared with 2008 production because of lower ore grades resulting from ore body development. The Porcupine and Musselwhite Mines produced 9,900 kg and 7,230 kg of gold, respectively, which was 9% and 10% more than in 2008, respectively, because of higher mill throughput and higher grades (Goldcorp Inc., 2010, p. 16–22).

In April, Barrick purchased the remaining 50% interest of the Hemlo Mine from Teck. Barrick's share of gold production at Hemlo in 2009 was 8,550 kg compared with 8,090 kg in 2008 (Barrick Gold Corp., 2010a, p. 56; 2010b).

Agnico-Eagle Mines Ltd. (Toronto) operated three mines in Quebec—the Goldex, Lapa, and LaRonde Mines. The Goldex Mine had its first full year of production and produced 4,630 kg of gold. On May 1, the Lapa underground mine achieved commercial production and produced 1,640 kg of gold. In 2009, the LaRonde Mine produced 6,700 kg of copper, 6,330 kg of gold, 121,000 kg of silver, and 56,200 kg of zinc. Agnico-Eagle gold production was 6% lower in 2009 than in 2008 owing to lower ore grades. In 2010, the company planned to open another mine, the Meadowbank in Nunavut Territory (Agnico-Eagle Mines Ltd., 2010, p. 14–16, 30).

Other mines either began production or had their first full year of production in 2009. In May, Apollo began production at its Black Fox Mine in Ontario and produced 1,650 kg of gold by yearend (Apollo Gold Corp., 2010). In October, St Andrew Goldfields Ltd.'s (Toronto) Holloway Mine in Ontario commenced production and produced 582 kg of gold (St Andrew Goldfields Ltd., 2010, p. 4). Alexis Minerals Corp.'s (Toronto) Lac Herbin Mine in Quebec produced 1,030 kg of gold in its first full year of production (Alexis Minerals Corp., 2010).

The increases were partially offset by output losses from NorthGate Minerals Corp.'s (Vancouver) Kemess South Mine in British Columbia and Vale S.A.'s (Rio de Janeiro, Brazil) Sudbury nickel operations in Ontario. In 2009, gold production from the Kemess South Mine was 5,380 kg, 7% less than production in 2008 because ore production was shifted to the eastern end of the pit when ore from the western end of the pit was exhausted (Northgate Minerals Corp., 2009, p. 33). Vale's Sudbury operations produced 1,520 kg of gold, which was 42% less than 2008 production because of a strike (Vale S.A., 2010, p. 43).

Chile.—In 2009, gold production was 40,800 kg, 4% more than that in 2008. The leading gold-producing mine was Yamana Gold's El Penon Mine, which produced 6,710 kg of gold, 4% less than in 2008. Yamana also produced 2,490 kg of gold from Minera Florida, 28% more than that in 2008 because of changes in mining methods (Yamana Gold Inc., 2010, p. 54, 57).

China.—China's production of gold increased by 12% to 320,000 kg compared with 2008 gold production. The increases in gold production were caused by the increase in gold prices, the low cost of labor, support from the central government, and consolidation of the gold mining industry. Historically, the gold mining industry has been greatly fragmented with a large number of small mines and mining companies. In 2009, 40% of the gold output was produced by the top five mining companies.

In 2009, Zijin Mining Group Co., Ltd. (Zijin, Guangdong Province) was the leading gold producer and produced more than 75,000 kg of gold, including 30,700 kg of its own mine-produced gold and 42,700 kg of gold refined from third party ores (Zijin Mining Group Co., Ltd., 2010). In 2009, Shandong Gold Group Co., Ltd. (Jinan, Shandong Province) and Zhaojin Mining Corp., Ltd. (Tianjin Municipality) produced 18,000 kg and 19,000 kg of gold, respectively (Klapwijk and others, 2010, p. 45).

Côte d'Ivoire.—In 2009, production of gold was 6,570 kg or 132% more than gold production in 2008 because of the first full year of production from Lihir Gold Ltd.'s (Port Moresby, Papua New Guinea) Bonikro Mine. In 2009, the mine produced 4,670 kg of gold (Lihir Gold Ltd., 2010, p. 10). In September, Cluff Gold fully commissioned its 90%-owned Angovia Mine and produced 519 kg of gold by yearend (Cluff Gold plc, 2010, p. 12).

Dominican Republic.—GlobeStar Mining Corp. (Toronto) started gold production in late 2008 and produced 3,750 kg of gold in 2009 at its Cerro de Maimon Mine (GlobeStar Mining Corp., 2010). Construction of the Barrick and Goldcorp jointly owned Pueblo Viejo project continued in 2009, and the mine was scheduled to start producing in late 2011. The project could produce an average of 31,000 kg of gold per year during the first 5 years of production (Redwood, 2010).

Ghana.—Production of gold in 2009 was 86,000 kg, which was 7% higher than that of 2008. Production from Newmont's Ahafo Mine was 16,500 kg, up slightly compared with 2008 gold production owing to an increase in tonnage of ore mined. In 2009, AngloGold's Obuasi and Iduapriem Mines produced 17,800 kg of gold, slightly more than 2008 production (AngloGold Ashanti Ltd., 2010, p. 74–77; Newmont Mining Corp., 2010, p. 28–29).

Gold Fields produced gold from two mines in 2009. The Tarwa Mine produced 20,700 kg of gold, 6% more than production in 2008. The Damang Mine produced 6,300 kg of gold, slightly more than 2008 production (Gold Fields Ltd., 2010, p. 1–8).

Red Back Mining Inc. (Vancouver) began commercial production from the underground mine at Akwaaba, which is part of the Chirano gold mine. In 2009, Chirano produced 5,710 kg of gold, which included 553 kg of gold from Akwaaba. Chirano's output was 52% more than 2008 production (Red Back Mining Inc., 2010, p. 2, 5).

In 2009, Golden Star Resources Ltd.'s (Littleton, CO) Wassa Mine benefited from higher grade ore from the Benso and the Hwini-Butre deposits. In 2008, mining commenced at the Benso deposit, and in 2009 mining operations started at the Hwini-Butre deposit. In 2009, production from the Wassa Mine was 6,960 kg of gold, 78% more than 2008 production. Golden Star's Bogoso gold mine produced 5,790 kg of gold in 2009, 9% more than that in 2008 (Golden Star Resources Ltd., 2010).

Guatemala.—In 2009, Guatemala's only gold-producing mine, Goldcorp's Marlin Mine, produced 14% more than in 2008 because of higher mill throughput (Goldcorp Inc., 2010, p. 26–27).

Guinea.—Gold production in 2009 fell by 9% compared with that of 2008. AngloGold's Siguiri Mine produced 11,600 kg of gold in 2009, 5% less than 2008 production because the high-grade areas were mined out in 2008. Crew Gold Corp. (Weybridge, United Kingdom) operated the LEFA Mine, which produced 5,520 kg of gold in 2009, 10% less than 2008 production because of lower mill capacity resulting from repairs to the semiautogenous grinding (SAG) mill (AngloGold Ashanti Ltd., 2010, p. 78–79; Crew Gold Corp., 2010, p. 25).

Indonesia.—In 2009, gold production rose to 130,000 kg, a 102% increase compared with 2008 gold production. Some of the leading gold producers were copper mines that produced byproduct gold. Freeport McMoRan's Grasberg Mine and Newmont-operated Batu Hijau Mine represented 60% (77,800 kg) and 13% (17,100 kg), respectively, of Indonesian gold production in 2009. Production at Batu Hijau and Grasberg recovered from the low levels in 2008 when heavy rains affected production (Freeport-McMoRan Copper & Gold Inc., 2010, p. 26; Newmont Mining Corp., 2010, p. 25–26). Offsetting some of the increases in production was Newcrest's Gosowong Mine, which produced 11,600 kg of gold, 11% less than 2008 production (Newcrest Mining Ltd, 2009a-c, 2010).

Kazakhstan.—KazakhGold Group Ltd.'s (London) operations produced 5,660 kg of gold in 2009, a slight increase compared with 2008 production because the company processed stockpiled ore and upgraded one of its concentrators (Mining Journal, 2010).

Kyrgyzstan.—Gold production for 2009 was 17,000 kg, a decrease of 7% compared with that in 2008. Centerra Gold Inc.'s (Toronto) Kumtor Mine produced 16,300 kg of gold in 2009, a 6% decrease compared with 2008 production because equipment that was supposed to be used for mining was instead used for waste and ice removal (Centerra Gold Inc., 2010, p. 4).

Mali.—AngloGold had interests in three gold mines in Mali—Morila (AngloGold and Randgold, 40% each, and Government of Mali, 20%), Sadiola [AngloGold and IAMGOLD Corp. (London), 38% each; Government of Mali, 18%; and International Finance Corp., 6%], and Yatela (AngloGold and IAMGOLD, 40% each, and Government of Mali, 20%). In 2009, these mines produced 28,600 kg of gold, 14% lower than gold production in 2008 (AngloGold Ashanti Ltd., 2008, p. 81–86).

The Morila Mine, 180 km southeast of the Bamako Mine, was operated by Randgold and produced 10,600 kg of gold in 2009. The 19% decrease in production compared with that of 2008 was because mining the open pit was completed in April, and the company was treating low-grade stockpiles. In 2010, production was projected to be about 2,800 kg of gold because only treatment of the low-grade stockpiles was scheduled to continue until 2013 (AngloGold Ashanti Ltd., 2010, p. 81–82).

The Sadiola operation consists of five open pits 77 km south of Kayes. In 2009, the operation produced 11,000 kg of gold, which was 22% less than production in 2008. The decrease was mainly caused by lower ore grades owing to the depletion of the Sadiola main pit reserves. In 2010, production was projected to decline; however, the addition of a gravity circuit could increase production in future years (AngloGold Ashanti Ltd., 2010, p. 83–84).

In 2009, the Yatela Mine, 25 km north of Kayes, produced 6,900 kg of gold, a 35% increase compared with 2008 production. The increase resulted from mining a high-grade area, which was expected to be mined out by early 2010 (AngloGold Ashanti Ltd., 2010, p. 85–86).

Randgold owned 80% of the Loulo Gold Mine; the other 20% was owned by the Government of Mali. In 2009, the mine produced 10,900 kg of gold, which was 36% more than 2008 production because of higher throughput, which was enabled by plant upgrades (Randgold Resources Ltd., 2010, p. 31–34).

Mauritania.—In 2009, production from Red Back Mining's Tasiast Gold Mine, the country's only primary gold mine, was 4,930 kg of gold, 13% more than 2009 production. First Quantum Minerals Ltd.'s (Vancouver) Guelb Moghrein copper and gold operation was the only other gold producer in 2009 (Red Back Mining Inc., 2010, p. 5).

Mexico.—In 2009, gold production reached an alltime high of 51,400 kg and was slightly higher than 2008 gold production. Goldcorp operated three mines in Mexico—El Sauzal, Los Filos, and San Dimas. The company also owned the Penasquito Mine, which was scheduled to begin commercial production in 2010. In 2009, El Sauzal produced 6,340 kg gold, a 26% decrease compared with gold production in 2008 owing to the age of the mine and anticipated lower ore grades. The Los Filos and San Dimas Mines produced 7,440 kg and 3,510 kg of gold, respectively, in 2009, 12% and 30% more, respectively, than gold production in 2008 because of higher tonnage mined at the Los Filos Mine and the higher ore grade at the San Dimas Mine. The Penasquito Mine began to approach full production, and in 2009, the mine produced 2,810 kg of gold (Goldcorp Inc., 2010, p. 21–25, 42).

Fresnillo plc (London) operated two gold mines and one silver mine with byproduct gold production. In 2009, Fresnillo's gold production was 8,600 kg, 5% more than 2008 gold production. Fresnillo also had limited production from the Saucito Mine, which was scheduled to start commercial production in 2011 (Fresnillo plc, 2010).

Other mines that had increased production in 2009 were New Gold's Cerro San Pedro Mine, which was in its second year of full production and produced 2,970 kg of gold, 13% more than that produced in 2008 (New Gold Inc., 2010). Alamos Gold Inc.'s (Toronto) Mulatos Mine produced 5,550 kg of gold, an increase of 18% because of higher gold recovery from heap leaching (Alamos Gold Inc., 2010, p. 2–3).

In May, Minefinders Corp. (Vancouver) began commercial production at the Dolores Mine and produced 2,400 kg of gold by yearend (Minefinders Corp., 2010, p. 1). Coeur d'Alene began gold production from its Palmarejo Mine in the second quarter and produced 1,700 kg by yearend (Coeur d'Alene Mines Corp., 2010, p. 4). On November 1, Agnico-Eagle started commercial production at the Pinos Altos Mine in Chihuahua State. The open pit operations produced 504 kg of gold in the first year of production. The company planned to begin underground operations in 2010 and expected to produce 4,700 kg of gold from both open pit and underground mining (Agnico-Eagle Mines Ltd., 2010, p. 18).

Mongolia.—Gold production in 2009 was 9,800 kg, 35% less than 2008 production owing to losses at Centerra Gold's Boroo gold mine. Gold production from the mine was 4,680 kg in 2009, which was lower because a labor strike temporarily shut down the mine (Centerra Gold Inc., 2010, p. 6).

New Zealand.—In 2009, gold production was 13,400 kg, a slight increase compared with production in 2008. Newmont's Waihi Mine produced 3,510 kg, 22% less than 2008 production because an electrical fire temporary suspended milling operations in May (Newmont Mining Corp., 2010, p. 66). In 2009, OceanaGold Corp. (Melbourne) produced 7,240 kg of gold from the Macraes Goldfield Mine, which was 27% more than 2008 production owing to the higher grades from the open pit and the Frasers underground operations. OceanaGold's other operation, the Reefton Goldfield Mine, produced 2,720 kg of gold in 2009, which was 15% more than production in 2008 (OceanaGold Corp., 2010, p. 13).

Papua New Guinea.—Production from Papua New Guinea mines decreased by 3% in 2009 compared with that in 2008. Barrick owned 95% of the Porgera Mine, and the Papua New Guinea Government held the remaining 5%. Barrick's share of production was 19,500 kg of gold in 2009, which was 12% higher than 2008 production (Barrick Gold Corp., 2010a, p. 57–58; b).

In 2009, Lihir produced 26,500 kg of gold, 11% more than that of 2008 from its Lihir Island operations because of the higher quantity of ore processed (Lihir Gold Ltd., 2009, p. 12–15). Production at Ok Tedi Mining Ltd.'s (Tabubil) Ok Tedi Mine was unchanged in 2009, and production at Allied Gold Ltd.'s (Milton, Australia) Simberi was 8% less than 2008 production (Klapwijk and others, 2010, p. 46).

Peru.—In 2009, gold production increased slightly to 182,000 kg compared with production in 2008; Peru was the sixth ranked gold-producing country in the world. Newmont and Compañía de Minas Buenaventura S.A.A. (Lima) jointly owned the Yanacocha Mine in the Cajamarca District, which produced 64,000 kg of gold in 2009, 39% more than in 2008 (Newmont Mining Corp., 2010, p. 24).

Buenaventura owned three other mines and a 35.78% share of another mine. In 2009, excluding production from the Yanacocha Mine, Buenaventura produced 13,200 kg, slightly more than production in 2008 (Compañía de Minas Buenaventura S.A.A., 2010, p. 3).

Barrick's Lagunas Norte Mine produced 31,300 kg of gold in 2009, 14% less than production in 2008, because of the planned mining of lower grade ore. As Barrick's Pierina Mine neared the end of its economic mine life, it produced 8,430 kg of gold, 32% less than production in 2008 (Barrick Gold Crop., 2010a, p. 43; b).

In 2009, its first full year of production, Gold Fields produced 10,300 kg of gold from the Cerro Corona copper and gold mine (Gold Fields Ltd., 2009, p. 1–8).

Russia.—Russian gold production in 2009 increased to 191,000 kg, 11% more than 2008 production. The leading gold producer in Russia was Polyus Gold Mining Co. (Moscow) with 39,000 kg of production from four mines and several alluvial deposits, a slight increase compared with 2008 production of 38,000 kg. Some of the increase was attributed to startup of the Titimukhta Mine and modernization of the Kuranakh Mine. In 2009, Polyus had two mines under construction and three other projects undergoing feasibility studies (Polyus Gold Mining Co., 2010, p. 4–9).

In its first full year of production, the Kupol Mine (75% owned by Kinross) produced 28,800 kg of gold. In 2010, production was expected to be lower because of lower projected ore grade. As of December 31, the mine had proven and probable reserves of 99,700 kg of gold (Kinross Gold Corp, 2010, p. 42, 145).

In 2009, Petropavlovsk plc (London), formerly Peter Hambro Mining plc, produced 15,100 kg of gold, an increase of 21% compared with production in 2008. Petropavlovsk produced gold from two open pit mines (Pioneer and Pokrovskiy), alluvial operations, and joint ventures. Much of the increase was attributed to the continued ramping up of Pioneer production, which had begun in 2008 (Petropavlovsk plc, 2010, p. 3–7).

Production from JSC Polymetal's (St. Petersburg) eight gold-producing mines increased by 9% to 9,670 kg in 2009. The increase was a result of the acquisition of mines and deposits (JSC Polymetal, 2010, p. 5).

In 2009, the Uzhuralzoloto Group of Companies (Moscow) (UGC) produced 5,300 kg of gold, slightly more than 2008 gold production. UGC had 10 gold mines in 4 regions of Russia (Uzhuralzoloto Group of Companies, 2010).

Highland Gold Mining Ltd. (St. Helier, United Kingdom) (HGM) produced 5,070 kg of gold in 2009. This was 3% more than production in 2008 because of increased mine production from its Mnogovershinnoye Mine (Highland Gold Mining Ltd., 2010, p. 1, 7–8).

GV Gold (Vysochaishy, OJSC) (Moscow) produced 3,450 kg of gold in 2009, 16% less than 2008 gold production. GV Gold had two operations, the Golets Vysochaishy operation in the Bodaibo Area of the Irkutsk Region and the Bolshoy Kuranakh placer gold operation in the Aldan Area of the Yakutia (Sakha) Republic [GV Gold (Vysochaishy, OJSC), 2010, p. 13–22].

High River Gold owned and operated three gold operations in 2009. The Zun-Holba and Irokinda underground mines produced 4,650 kg of gold, which was slightly more than 2008 production. Production for the Berezitovy open pit mine was 2,720 kg of gold in 2009. With better mill availability, Berezitovy produced 458% more gold in 2009 than in 2008 (High River Gold Mines Ltd., 2010).

Senegal.—In 2009, Senegal opened its first major gold mine. In March, Mineral Deposits Ltd. (Melbourne) finished construction of Sabodala gold mine and produced 4,980 kg of gold by yearend (Mineral Deposits Ltd., 2010, p. 2).

South Africa.—In 2009, South Africa's gold production of 198,000 kg was a 7% decrease from that in 2008 owing to a significant increase in labor costs, higher costs associated with deep-level shafts, new royalties on mining revenue, and power issues. In addition, mine production was hindered because of a temporary closure of shafts owing to mine accidents. Companies continued to have problems with finding and retaining a trained labor force and with competition with illegal miners (Klapwijk and others, 2010, p. 39–41).

In 2009, three companies operated mines that accounted for more than 80% of South African gold production. They were, in descending order of production, Gold Fields, AngloGold, and Harmony Gold Mining Co., Ltd. (Randfontein).

In 2008, Gold Fields's South African operations produced 65,200 kg of gold, slightly more than 2008 production from the Beatrix, Driefontein, Kloof, and South Deep Mines. Only the South Deep Mine increased production in 2009 because of an increase in the amount of ore processed. Safety-related work stoppages were responsible for a decreases in production at the company's other mines (Gold Fields Ltd., 2009, p. 1–8).

AngloGold had seven deep-level mines and one surface operation in the West Wits and Vaal River regions that, combined, produced 55,900 kg of gold in 2009, 14% less than that in 2008. In 2009, West Wits operations included the Mponeng, Savuka, and Tau Tona Mines and produced 23,900 kg of gold. The Vaal River operations included the Great Noligwa, Kopanang, Moab Khotsong, and Tau Lekoa Mines. The production decrease was attributed to the decreases in ore grade and reduced ore volume. In 2009, there were 13 fatalities and 938 accidents at AngloGold's South African operations. These incidents resulted in a loss of 95 full production shifts and 73 partial production shifts. In March, an underground fire disrupted ore production at the Great Noligwa Mine. In May, a seismic event significantly damaged underground infrastructure at the Savuka Mine. In October, inspection and repair of all shaft steelworking following a steel dislodgement from the shaft wall at the Tau Tona Mine resulted in an 8-week work stoppage (AngloGold Ashanti Ltd., 2010, p. 52–69).

Harmony operated 10 underground mines, 2 surface operations, and several other gold-producing operations in South Africa. In 2009, production from Harmony's operations was 44,400 kg of gold, 3% less than that in 2008. Underground operations were relatively unchanged as increases from the Doornkop and Phakisa projects and the Target Mine more than offset decreased production from the Evander and Virginia operations. Much of the decrease was from the surface operations. In 2009, Kalgold surface operations produced 38% less gold than in 2008 because the company processed lower ore grades (Harmony Gold Mining Co., Ltd., 2010, p. 6–11).

Simmer and Jack Mines Ltd. (Johannesburg) had two operations in 2009—the Buffelsfontein gold mine and the Transvall gold mining estates. In 2009, these mines produced 4,010 kg of gold, slightly less than in 2008 (Simmer and Jack Mines Ltd., 2010, p. 6–12).

In 2009, increased output from platinum-group metal mines resulted in increased byproduct gold production. Gold One International Ltd. (Sydney) commissioned the Modder East Mine, and DRDGold South African Operations Pty. Ltd. (Randburg) recommissioned its Ergo tailings plant. First Uranium Corp. (Toronto) began first commercial production from its Ezulwini underground operations and continued to build capacity at its Mines Waste Solutions (MWS). However, permitting problems at MWS have limited its production and threatened the project, and ore production rates at the Ezulwini operations were less than predicted (First Uranium Corp., 2010, p. 1–5; Klapwijk and others, 2010, p. 39–41).

Suriname.—IAMGOLD's Rosbel Mine was the leading gold mine in the country in terms of production with 12,200 kg produced, 24% more than in 2008. The increase was attributed to higher throughput because of mill expansion (IAMGOLD Corp., 2010, p. 33, 35).

Tanzania.—In 2009, gold production increased by 10% to 40,000 kg, compared with 2008 production. Gold production from Barrick's operations was 22,300 kg, an increase of 31% from that of Barrick's share of production in 2008. In May, Barrick's fully owned Buzwagi Mine started production and produced 5,880 kg of gold. Barrick's other fully owned mines, the Balyanhulu and North Mara Mines, produced 25% and 8% more gold, respectively, in 2009 compared with 2008 production. At the Balyanhulu Mine, production returned to normal levels after a strike in 2007–08 resulted in lower production levels. These increases were partially offset by production losses at the Tulawaka gold mine [70% owned by Barrick and 30% owned by Northern Mining Explorations Ltd. (Montreal)], where production decreased by 55% in 2009 compared with production in 2008 because of a planned shift from open pit to underground mining (Barrick Gold Corp., 2010a, p. 58–59; b).

AngloGold's Geita Mine produced 8,460 kg of gold in 2009, 3% more than production in 2008. Improvements in ore grades in the second half of the year were the main reason for the increase; however, some of this increase was offset by mill breakdowns in the first quarter (AngloGold Ashanti Ltd., 2010, p. 87–88).

Turkey.—Gold production in 2009 was 12,000 kg, an increase of 8% compared with that of 2008. The Eldorado Gold Kisladag Mine, the leading gold mine in Turkey, produced 7,380 kg of gold, 25% more than in 2008. The mine had restarted in the third quarter of 2008 and produced for a full year in 2009 (Eldorado Gold Corp., 2010, p. 10).

Uzbekistan.—According to the Uzbekistani Government, the country had the fourth leading gold reserves in the world and was the ninth leading gold producer. State-owned Navoi Mining and Metallurgical Combine (Navoi) (NGMK) owned the Muruntau gold mine in Zarafshan. The mine reportedly produced about 70% of the country's gold production (Musaev and Aminov, 2010).

Outlook

Worldwide and domestic gold production was expected to increase in 2010 because of new mines starting production and older mines expanding production. However, gold consumption was expected to continue to decrease because the higher gold prices would limit gold jewelry purchases. Investment in gold in various forms was expected to continue to increase as investors purchase gold as a safe haven, hedge against economic failures, portfolio diversifier, and as a store of wealth.

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TABLE 1

SALIENT GOLD STATISTICS[1]

		2005	2006	2007	2008	2009
United States:						
Production:						
Mine:						
Quantity	kilograms	256,000	252,000	238,000	233,000	223,000
Value	thousands	$3,670,000	$4,910,000	$5,350,000	$6,550,000	$7,000,000
Gold recovered by cyanidation:						
Extracted in vats, tanks, closed containers[2]	kilograms	W	W	W	W	W
Leached in open heaps or dumps[3]	do.	229,000	217,000	207,000	194,000	188,000
Refinery:						
Concentrates and dore	do.	195,000	181,000	176,000	168,000	170,000
Recycled materials (new and old scrap)	do.	81,300	89,100	135,000	181,000	189,000
Exports, refined	do.	182,000	228,000	392,000	459,000 [r]	281,000
Imports for consumption, refined	do.	105,000	136,000	113,000	118,000	127,000
Net deliveries from foreign stocks in Federal Reserve Bank of New York	do.	--	--	189,000	220,000	--
Stocks, December 31:						
Industry[4]	do.	2,040	2,000	1,140	W	9,200
Gold exchange traded funds holdings, United States only	do.	285,000	498,000	683,000	847,000	1,210,000
COMEX	do.	211,000	234,000	229,000	265,000	305,000
U.S. Department of the Treasury	metric tons	8,140	8,140	8,140	8,140	8,140
U.S. Gold Futures Trading[5]	do.	49,400	49,500	77,900	119,000	110,000
Consumption:						
American Buffalo Bullion gold coin[6]	kilograms	--	10,500	4,250	5,890	6,220
American Eagle gold coin[6]	do.	13,800	9,770	12,800	35,600	44,300
In industry and the arts	do.	183,000	185,000	180,000	176,000	150,000
Price, average[7]	dollars per troy ounce	446.20	605.83	698.95	873.50	974.68
Employment, mine and mill only[8]		7,910	8,350	9,130	9,560	9,630
World:						
Production, mine	kilograms	2,470,000	2,370,000	2,360,000 [r]	2,290,000 [r]	2,450,000 [e]
Official bullion reserves[9]	metric tons	30,800	30,400	29,900	28,700	30,700

[e] Estimated. [r] Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits, except prices.

[2] May include small quantities recovered by gravity methods.

[3] May include tailings, waste-ore dumps, and previously mined ore at some inactive mines.

[4] Unfabricated refined gold held by refiners, fabricators, dealers, and the U.S. Department of Defense.

[5] COMEX only.

[6] Data from U.S. Mint.

[7] Engelhard quotation.

[8] Data from the Mine Safety and Health Administration.

[9] Held by central banks, governments, and international monetary organizations. Data from the International Monetary Fund.

TABLE 2

MINE PRODUCTION OF GOLD IN THE UNITED STATES, BY STATE[1]

(Kilograms)

State	2008	2009
Nevada	178,000	161,000
Other States[2]	55,400	62,500
Total	233,000	223,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes Alaska, Arizona, California, Colorado, Idaho, Montana, New Mexico, South Dakota, Utah, and Washington.

TABLE 3

LEADING GOLD-PRODUCING MINES IN THE UNITED STATES IN 2009, IN ORDER OF OUTPUT[1]

Rank	Mine	County and State	Majority owner	Quantity (kilograms)
1	Goldstrike[2]	Elko and Eureka, NV	Barrick Gold Corp.	42,100
2	Eastern Nevada Operations[3]	Eureka, NV	Newmont Mining Corp.	36,500
3	Bingham Canyon[4]	Salt Lake, UT	Kennecott Utah Copper Corp.[5]	18,100
4	Cortez[6]	Lander, NV	Barrick Gold Corp.	16,100
5	Twin Creeks	Humboldt, NV	Newmont Mining Corp.	13,600
6	Smoky Valley Common Operation	Nye, NV	Kinross Gold Corp.	13,300
7	Pogo	Southeast Fairbanks, AK	Sumitomo Metal Mining Co.	12,100
8	Fort Knox[7]	Fairbanks North Star, AK	Kinross Gold Corp.	8,190
9	Phoenix	Lander, NV	Newmont Mining Corp.	6,800
10	Cresson	Teller, CO	AngloGold Ashanti Ltd.	6,780
11	Turquoise Ridge	Humboldt, NV	Barrick Gold Corp.	5,520
12	Kettle River-Buckhorn	Okanogan, WA	Kinross Gold Corp.	5,400
13	Mesquite	Imperial, CA	New Gold Inc.	4,670
14	Marigold	Humboldt, NV	Goldcorp Inc.	4,570
15	Midas	Elko, NV	Newmont Mining Corp.	3,850
16	Ruby Hill	Eureka, NV	Barrick Gold Corp.	3,220
17	Robinson	White Pine, NV	Quadra Mining Ltd.	3,080
18	Bald Mountain	do.	Barrick Gold Corp.	2,330
19	Wharf	Lawrence, SD	Wharf Resources Inc.[8]	2,110
20	Greens Creek	Juneau, AK	Hecla Mining Co.	2,090
21	Storm	Elko, NV	Barrick Gold Corp.	2,000
22	Florida Canyon	Pershing, NV	Jipangu Inc.	1,390
23	Hycroft	Humboldt and Pershing, NV	Allied Nevada Gold Corp.	1,320
24	Hollister	Elko, NV	Great Basin Gold Ltd.	970
25	Golden Sunlight	Jefferson, MT	Barrick Gold Corp.	871
26	Denton-Rawhide	Mineral, NV	Kennecott Minerals Co.[5]	602
27	Rochester	Pershing, NV	Coeur d'Alene Mines Corp.	395
28	Lone Tree[9]	Humboldt and Lander, NV	Newmont Mining Corp.	374
29	Briggs	Inyo, CA	Atna Resources Ltd.	348
30	Jerritt Canyon	Elko, NV	Yukon-Nevada Gold Corp.	304

do. Ditto.

[1] Data are rounded to no more than three significant digits; the mines on this list accounted for more than 99% of U.S. mine production in 2009.

[2] Formerly listed as Betze-Post Mine.

[3] Includes Carlin East, Deep Post, Gold Quarry, and Pete Mines.

[4] Quantity refers to total quantity of gold produced in concentrates.

[5] Wholly owned subsidiary of Rio Tinto plc.

[6] Includes Cortez Hills and Cortez Pipeline Mines.

[7] Quantity refers to gold equivalent produced (that is, includes value of associated metals).

[8] Wholly owned subsidiary of Goldcorp Inc.

[9] Includes Mule Canyon and Trenton Canyon Mines.

Sources: Company annual reports, company 10–K reports submitted to the Securities and Exchange Commission, company news releases, and Nevada Bureau of Mines and Geology.

TABLE 4
U.S. EXPORTS OF GOLD, BY COUNTRY[1, 2]

	Ores and concentrates[3]		Dore and precipitates		Refined bullion[4]		Total	
Year and country	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
2008	2,430	$52,300	106,000	$3,000,000	459,000 r	$13,100,000	567,000	$16,200,000
2009:								
Australia	88	2,690	--	--	26,600	900,000	26,700	903,000
Austria	--	--	61	1,870	21	797	81	2,660
Bahrain	--	--	--	--	31	1,040	31	1,040
Bolivia	--	--	--	--	17	226	17	226
Brazil	1	20	--	--	136	2,150	137	2,170
Canada	37	609	243	6,990	2,830	89,900	3,110	97,500
China	(5)	3	--	--	51	1,500	51	1,510
Costa Rica	484	10,500	--	--	53	1,510	537	12,000
France	5	128	--	--	99	2,480	104	2,610
Germany	88	2,550	82	1,810	661	18,300	832	22,700
Guatemala	(5)	5	1	16	9	256	10	277
Hong Kong	159	3,420	--	--	684	19,500	844	22,900
India	2	10	--	--	21,000	633,000	21,000	633,000
Indonesia	--	--	--	--	9	339	9	339
Ireland	239	3,130	--	--	4	66	244	3,190
Israel	--	--	--	--	8	211	8	211
Italy	(5)	4	--	--	21	576	21	580
Jordan	14	355	--	--	4	128	18	483
Korea, Republic of	70	2,470	--	--	--	--	70	2,470
Lebanon	--	--	--	--	20	400	20	400
Malaysia	--	--	--	--	361	10,200	361	10,200
Mexico	790	19,900	--	--	2,330	66,300	3,120	86,200
Pakistan	--	--	--	--	25	821	25	821
Peru	--	--	95	2,870	--	--	95	2,870
Poland	--	--	--	--	8	194	8	194
Singapore	5	98	--	--	74	2,150	79	2,250
Switzerland	6	63	96,700	2,980,000	6,270	166,000	103,000	3,150,000
Turkey	8	75	--	--	60	1,310	68	1,390
United Arab Emirates	--	--	--	--	147	4,390	147	4,390
United Kingdom	110	2,000	154	3,330	219,000	6,840,000	220,000	6,840,000
Vietnam	9	176	--	--	58	1,330	67	1,500
Other	47	483	2	33	27	591	74	1,110
Total	2,160	48,600	97,400	3,000,000	281,000	8,760,000	381,000	11,800,000

rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Ash and residues data were zero for listed years.

[3] Includes base-metal ores, concentrates, and matte destined for refining.

[4] Bullion also moves in both directions between U.S. markets and foreign stocks on deposit in the Federal Reserve Bank. Monetary gold is excluded.

[5] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 5

U.S. EXPORTS OF GOLD, BY COUNTRY[1]

	Waste and scrap		Metal powder		Gold compounds	
Year and country	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
2008	886,000	$1,970,000	1,210	$25,300	2,920,000	$67,900
2009:						
Belgium	183,000	18,500	--	--	--	--
Bolivia	--	--	1	10	650	12
Brazil	--	--	--	--	870	8
Canada	76,500	1,510,000	21	270	531,000	9,560
China	--	--	1	5	331,000	10,500
Colombia	--	--	--	--	1,880	34
Dominican Republic	1	15	--	--	201,000	4,010
Ecuador	--	--	--	--	1,780	18
France	8	129	(2)	9	759	14
Germany	112,000	48,900	8	91	44,000	798
Guatemala	70	640	5	124	--	--
Hong Kong	1	45	19	408	33,000	404
India	2	14	56	1,620	5,920	107
Ireland	--	--	--	--	14,700	265
Israel	--	--	2	15	10,900	197
Italy	1,500	2,340	--	--	673	46
Japan	619	16,700	16	419	2,180	19
Korea, Republic of	--	--	1	30	5,530	99
Lebanon	--	--	--	--	683	12
Malaysia	--	--	--	--	90,600	1,630
Mexico	--	--	14	195	20,200	370
Netherlands	--	--	4	115	11,200	201
Norway	21	235	--	--	69	3
Singapore	--	--	3	11	1,240,000	33,900
Sweden	--	--	--	--	318	6
Switzerland	2,730	76,000	6	170	--	--
Taiwan	--	--	12	252	125,000	2,250
Thailand	(2)	4	1	34	694	12
Turkey	--	--	70	1,960	--	--
United Arab Emirates	185	4,410	--	--	--	--
United Kingdom	351,000	79,900	85	2,690	8,860	104
Other	1	18	4	31	161	3
Total	728,000	1,750,000	329	8,460	2,680,000	64,600

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 6

U.S. IMPORTS FOR CONSUMPTION OF GOLD, BY COUNTRY[1]

Year and country	Ores and concentrates[2]		Dore and precipitates		Refined bullion[3]		Total	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
2008	27,500	$15,700	85,100	$1,830,000	118,000	$3,190,000	231,000	$5,050,000
2009:								
Argentina	--	--	203	7,440	168	5,450	371	12,900
Australia	13	168	--	--	665	21,800	678	21,900
Austria	--	--	--	--	1,620	43,300	1,620	43,300
Belgium	--	--	--	--	50	941	50	941
Bolivia	--	--	47	1,350	11	409	59	1,760
Brazil	--	--	--	--	3,270	97,600	3,270	97,600
Canada	90	1,160	1	29	66,300	2,070,000	66,300	2,070,000
Chile	--	--	3,940	86,400	4,950	151,000	8,890	237,000
Colombia	--	--	22,100	630,000	14,300	397,000	36,400	1,030,000
Congo (Kinshasa)	--	--	5	143	2	70	7	213
Costa Rica	--	--	933	17,400	6	99	939	17,500
Dominican Republic	--	--	776	15,100	146	2,680	922	17,800
Ecuador	--	--	281	7,840	297	6,490	579	14,300
El Salvador	--	--	6	102	4	117	10	219
France	--	--	--	--	25	914	25	914
Germany	--	--	--	--	78	2,450	78	2,450
Ghana	80	2,000	30	968	23	600	133	3,570
Guatemala	--	--	8,070	295,000	--	--	8,070	295,000
Guinea	--	--	--	--	30	887	30	887
Guyana	--	--	2,400	76,600	201	7,150	2,600	83,800
Honduras	--	--	2,470	68,500	11	337	2,480	68,800
Hong Kong	--	--	1	43	93	2,900	95	2,940
Japan	--	--	--	--	15	429	15	429
Mexico	46,500	29,800	79,400	2,270,000	26,300	556,000	152,000	2,850,000
Netherlands Antilles	--	--	591	18,400	25	906	616	19,300
Nicaragua	--	--	1,200	37,600	115	1,280	1,310	38,800
Panama	--	--	445	12,200	392	9,090	837	21,300
Peru	--	--	19,500	602,000	15	466	19,500	603,000
South Africa	--	--	--	--	1,500	50,300	1,500	50,300
Spain	--	--	125	3,340	21	719	146	4,060
Sweden	--	--	--	--	46	1,260	46	1,260
Switzerland	--	--	1,560	55,000	3,120	105,000	4,680	160,000
Thailand	--	--	--	--	29	938	29	938
United Arab Emirates	--	--	--	--	13	411	13	411
United Kingdom	--	--	2,160	51,100	2,830	41,000	4,990	92,100
Venezuela	--	--	--	--	152	3,980	152	3,980
Other	--	--	13	204	33	645	45	848
Total	46,600	33,100	146,000	4,260,000	127,000	3,580,000	320,000	7,870,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes base-metal ores, concentrates, and matte destined for refining.

[3] Bullion also moves in both directions between U.S. markets and foreign stocks on deposit in the Federal Reserve Bank. Monetary gold is excluded.

Source: U.S. Census Bureau.

TABLE 7

U.S. IMPORTS FOR CONSUMPTION OF GOLD, BY COUNTRY[1]

	Waste and scrap		Metal powder		Gold compounds	
Year and country	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
2008	36,500	$485,000	324	$6,620	102,000	$2,210
2009:						
Bahamas, The	79	629	(2)	3	--	--
Belize	162	787	--	--	--	--
Bolivia	131	3,100	--	--	--	--
Canada	5,290	85,200	22	386	2,280	104
Cayman Islands	13	228	--	--	--	--
China	8	111	--	--	--	--
Colombia	88	1,940	--	--	--	--
Costa Rica	1,770	18,400	--	--	--	--
Dominican Republic	9,990	171,000	3	27	--	--
Ecuador	6	107	--	--	--	--
El Salvador	3,680	52,400	--	--	--	--
Germany	8	102	101	2,360	3,860	92
Ghana	--	--	89	1,850	--	--
Greece	11	194	--	--	--	--
Guatemala	1,270	9,210	--	--	--	--
Honduras	5,630	81,900	--	--	--	--
India	25	918	--	--	--	--
Israel	--	--	6	224	--	--
Italy	165	2,250	(2)	3	--	--
Jamaica	164	2,050	--	--	--	--
Japan	1	3	(2)	3	19,800	504
Korea, Republic of	12	323	--	--	--	--
Malaysia	69	809	--	--	--	--
Mexico	11,600	122,000	63	823	--	--
Netherlands	--	--	--	--	11,600	238
Netherlands Antilles	364	6,120	1	5	--	--
Nicaragua	1,310	18,400	8	152	--	--
Panama	1,080	14,200	22	620	--	--
Sierra Leone	2	66	110	1,710	--	--
Singapore	28	526	--	--	--	--
Slovakia	13	147	--	--	--	--
St. Lucia	38	384	--	--	--	--
Switzerland	--	--	7	192	--	--
Taiwan	44	512	--	--	--	--
Thailand	66	1,560	--	--	--	--
United Kingdom	146	1,190	1	12	26,600	486
Venezuela	87	2,470	--	--	--	--
Other	50	345	45	389	78	5
Total	43,400	600,000	476	8,760	64,300	1,430

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8
GOLD: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Kilograms)

Country	2005	2006	2007	2008	2009[e]
Algeria	697	377	236	656[r]	1,010
Argentina	27,904	44,131	42,021	42,046[r]	47,000
Armenia[e]	1,300[r]	1,300[r]	1,300[r]	1,359[r, 3]	944[3]
Australia	262,000	247,000	247,000[e]	215,000	222,000
Azerbaijan	--	--	--	--	353
Belize[e]	--	5[3]	5	5	5
Benin[e]	20	24	19	20	20
Bolivia	8,871	9,628	8,818	8,405[r]	7,000[p, 3]
Botswana[e]	2,770[3]	2,800	2,800	3,300[r]	2,000
Brazil[4]	38,293	43,082	50,000[r]	54,000[r]	60,000[p]
Bulgaria	3,868	3,818	3,964	4,160[r]	4,200
Burkina Faso	1,397	1,571	2,250	7,633	13,500[3]
Burma[e]	90	100	100	100	100
Burundi[e]	750	750	750	750	750
Cameroon[e]	1,500	1,500	1,500	1,500	1,600
Canada	119,549	103,513	102,211	95,004	97,367[3]
Central African Republic[e]	15	10	10	10	10
Chad[e]	150	150	150	100[r, e]	100
Chile	40,447	42,100	41,527	39,162	40,834[3]
China[e]	225,000	245,000	275,000	285,000	320,000
Colombia	35,783	15,683[r]	15,482	34,321[r]	47,837[3]
Congo (Brazzaville)[e]	120	100	100	100	100
Congo (Kinshasa)[e]	7,200[r]	10,300[r]	5,100[r]	3,300[r]	2,000
Costa Rica	424	1,210	2,065	198[r]	500
Côte d'Ivoire	1,335	1,324	1,243	2,836[r]	6,573[3]
Denmark[5]	2,324	1,129	1,861	1,665	1,117[3]
Dominican Republic	--	--	--	47	173
Ecuador[6]	5,338	5,168	3,186	800[r, e]	2,092[3]
Equatorial Guinea[e]	200	200[r]	200[r]	200[r]	200
Eritrea[e]	30[3]	30	30	30	30
Ethiopia[7]	4,376	4,028	4,368[r]	3,465[r]	3,400
Fiji	3,236[r]	1,961[r]	837[r]	871[r]	1,040
Finland[e]	5,000	5,000	5,000	5,000	7,000
France[e]	1,500[3]	1,500	1,500	1,500	1,500
French Guiana[e]	1,955[3]	2,000	2,000	2,000	2,000
Gabon[e, 8]	300	300	300	300	300
Georgia[e]	2,000	2,000	2,000	2,000	2,000
Ghana	66,852	69,817	83,558	80,503	86,000[3]
Greece	--	--	--	400	500
Guatemala	741	5,036	7,068	7,448[r]	8,485[3]
Guinea	25,097	16,922	15,628	19,945	18,083[3]
Guyana	8,325[r]	5,668[r]	7,412[r]	8,131[r]	8,183[3]
Honduras	4,438	4,100[e]	3,275	2,561[r]	2,127[3]
India[9]	3,100	2,400	3,000[e]	2,700	2,800
Indonesia[10]	130,620	93,176	117,851	64,390[r]	130,000
Iran[e]	200	200	252[r, 3]	400	400
Italy[e]	150	200[3]	450	450	450
Japan	8,318	8,904	8,869	6,868	7,000[3]
Kazakhstan[e]	18,062[3]	20,000	22,000	22,000	22,000
Kenya	616	432	3,023[r]	340[r]	300
Korea, North[e]	2,000	2,000	2,000	2,000	2,000

See footnotes at end of table.

TABLE 8—Continued
GOLD: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Kilograms)

Country	2005	2006	2007	2008	2009[e]
Korea, Republic of	266	277	162	175	175
Kyrgyzstan	16,700 [e]	10,721	10,559	18,132	16,950 [3]
Laos	7,058	6,088	4,161	4,300 [r]	5,000
Liberia	27	9	311 [e]	624 [r]	600
Madagascar[e]	10 [r]	30 [r]	50 [r]	72 [r, 3]	70
Malaysia	4,250	3,497	2,913	2,489 [r]	2,794 [3]
Mali	44,230	51,957	48,850	41,160	42,000
Mauritania	--	322	2,251	6,254 [r]	8,000
Mexico	30,356	38,961	39,355	50,365	51,393 [3]
Mongolia	24,120	22,561	17,473	15,184	9,803 [3]
Morocco[e]	1,200	1,200	1,200	1,200	1,200
Mozambique	63	85	97 [r]	298 [r]	511 [3]
Namibia	2,703	2,790	2,496 [r]	2,126 [r]	2,022 [3]
New Zealand	10,583	10,618	10,638	13,402 [r]	13,442 [3]
Nicaragua[e]	3,674 [3]	3,595 [3]	3,400	3,400	3,400
Niger	4,962	2,615	3,427 [r]	2,314 [r]	2,000
Nigeria[e]	30	40	180	200	200
Oman	384	186 [r]	124 [r]	46 [r]	28 [3]
Panama	--	--	--	--	800
Papua New Guinea	68,483	58,349	65,000 [e]	68,000	66,000
Peru[11]	208,002	202,826	170,236	179,872 [r]	182,391 [3]
Philippines	37,490	36,141	38,792	35,726 [r]	37,047 [3]
Poland	713	1,700	883	902	814
Romania[e]	400	400	400	400	400
Russia[12]	164,186	159,340	156,975	172,031 [r]	190,693 [3]
Rwanda[e]	10	15	17 [3]	20	20
Saudi Arabia	7,456	5,200 [e]	4,440	4,527	5,500 [3]
Senegal[e]	600	600	600	600	5,600
Serbia[e]	335 [3, 13]	450	500	500	500
Sierra Leone	53	71	212 [e]	196 [r]	200
Slovakia	109	84	92 [e]	198 [r]	200
Solomon Islands[e]	10	10	--	--	--
South Africa	294,671	272,128	252,598 [r]	212,744	197,698 [3]
Spain	3,971 [r]	3,421 [r]	3,500 [e]	3,400 [r]	3,450 [p]
Sudan	3,625	3,158	2,703	2,276	1,922 [3]
Suriname	10,619	9,362	9,360 [r, e]	9,798 [r]	12,193 [3]
Sweden[e]	5,100	5,100	5,000	5,000	5,000
Tajikistan	1,927 [r]	1,920 [r]	2,000 [r]	1,672 [r]	1,361 [3]
Tanzania	52,276	47,000 [e]	40,193	36,434 [r]	40,000
Thailand	4,400	4,300 [r]	3,401 [r]	2,721	3,000
Turkey	4,170	8,040	9,920	11,120	12,000
Uganda[e]	1,700 [3]	1,600	1,600	1,500	1,600
United Kingdom	--	--	--	164	185
United States	256,000	252,000	238,000	233,000	223,000 [3]
Uruguay	3,151	3,000 [r]	2,820 [r]	2,182 [r]	2,180 [p]
Uzbekistan[e]	90,000	85,000	85,000	85,000	90,000
Venezuela[e]	10,480 [r]	11,600 [r]	10,092 [r]	10,100 [r]	10,500 [p]
Vietnam[e]	2,138 [3]	2,500	3,000	3,000	3,000
Zambia	440 [r]	956 [r]	1,270 [r]	1,930 [r]	1,500 [3]
Zimbabwe	14,023	11,354	6,750	3,600	4,200
Total	2,470,000	2,370,000	2,360,000 [r]	2,290,000 [r]	2,450,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

TABLE 8—Continued

GOLD: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

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[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 19, 2010.

[3] Reported figure.

[4] Officially reported figures are as follows, in kilograms: Major companies: 2005—29,942; 2006—37,907 (revised); 2007—44,790 (revised); 2008—48,373 (revised); and 2009—48,000 (estimated). Garimpos: 2005—8,351; 2006—5,175; 2007—5,210 (revised); 2008—5,627 (revised); and 2009—6,000 (estimated).

[5] All production from Greenland.

[6] Includes undocumented artisanal production.

[7] Year ending July 7 of that stated.

[8] Undocumented artisanal production.

[9] Refinery output.

[10] Excludes production from so-called people's mines, which may be as much as 20,000 kilograms per year, but includes gold recovered as byproduct for copper mining.

[11] Includes documented production from placer artisanal production.

[12] Mine output including gold recovered as a byproduct, but excludes secondary gold production, which, in kilograms, was 2005—4,882; 2006—4,981; 2007—5,867; 2008—8,140 (revised); and 2009—12,404.

[13] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

GRAPHITE

By Donald W. Olson

Domestic survey data and tables were prepared by Danielle L. Militello, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2009, there was no reported production of natural graphite, but U.S. production of synthetic graphite was estimated to be 118,000 metric tons (t) valued at about $998 million. U.S. imports and exports of natural graphite were estimated to be 33,100 t and 11,400 t, respectively, while U.S. imports and exports of synthetic graphite were estimated to be 29,400 t and 35,000 t, respectively. U.S. apparent consumption of natural and synthetic graphite was estimated to be 21,700 t and 112,000 t, respectively.

This report includes information on U.S. trade and use of natural graphite and U.S. production, trade, and use of synthetic graphite. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using the unrounded data.

Graphite is one of four forms of crystalline carbon; the others are carbon nanotubes, diamonds, and fullerenes. Graphite is gray to black in color, opaque, and usually has a metallic luster; sometimes it exhibits a dull earthy luster. Graphite occurs naturally in metamorphic rocks. It is a soft mineral with a Mohs hardness of 1 to 2, and it exhibits perfect basal (one-plane) cleavage. Graphite is flexible but not elastic, has a melting point of 3,927 °C, and is highly refractory. It has a low specific gravity. Graphite is the most electrically and thermally conductive of the nonmetals and is chemically inert. All these properties combined make graphite desirable for many industrial applications, and both natural and synthetic graphite have industrial uses.

There are three types of natural graphite—amorphous, flake or crystalline flake, and vein or lump. Amorphous graphite is the lowest quality and most abundant. Amorphous refers to its very small crystal size and not to a lack of crystal structure. Amorphous is used for lower value graphite products and is the lowest priced graphite. Large amorphous graphite deposits are found in China, Europe, Mexico, and the United States. Flake or crystalline flake graphite is less common and higher quality than amorphous. Flake graphite occurs as separate flakes that crystallized in metamorphic rock. Flake graphite can be four times the price of amorphous. Good quality flakes can be processed into expandable graphite for many uses, such as flame retardants. The foremost deposits are found in Austria, Brazil, Canada, China, Germany, and Madagascar. Vein or lump graphite is the rarest, most valuable, and highest quality type of natural graphite. It occurs in veins along intrusive contacts in solid lumps, and it is only commercially mined in Sri Lanka (Moores, 2007).

Natural graphite is mined from open pit and underground mine operations. Production from open pit operations is less expensive and is preferred where the overburden can be removed economically. Mines in Madagascar are mostly of this type. In Mexico, the Republic of Korea, and Sri Lanka, where the deposits are deep, underground mining techniques are required.

Beneficiation processes for graphite may vary from a complex four-stage flotation at European and United States mills to simple hand sorting and screening of high-grade ore at Sri Lankan operations. Certain soft graphite ores, such as those found in Madagascar, need no primary crushing and grinding. Typically, such ores contain the highest proportion of coarse flakes. Ore is sluiced to the field washing plant, where it undergoes desliming to remove the clay fraction and is subjected to a rough flotation to produce a concentrate with 60% to 70% carbon. This concentrate is transported to the refining mill for further grinding and flotation to reach 85% carbon. It is then screened to produce a variety of products marketed as flake graphite that contain 75% to 90% carbon.

Production

The U.S. Geological Survey (USGS) obtained the production data in this report through a voluntary survey of U.S. synthetic graphite producers. The survey of U.S. synthetic graphite producers collected data from 11 of 16 canvassed producers. Data were estimated for the producers that did not respond to the survey based on responses received in previous years and on industry trends.

No natural graphite was reported mined in the United States in 2009, but 118,000 t of synthetic graphite with an estimated value of $998 million was produced and shipped (table 3).

Consumption

The USGS obtained the data in this report through a survey of natural graphite companies in the United States. The survey of natural graphite companies collected data from 55 of 90 canvassed companies and plants. Data were estimated for the companies that did not respond to the survey. This survey represented most of the graphite industry in the United States.

Graphite uses have changed dramatically in the past 20 years. U.S. reported consumption of natural graphite decreased by 20% to 40,000 t in 2009 from 49,800 t in 2008 (table 2), owing to decreases of 11%, 58%, 18%, and 17% from the previous year in the amounts of natural graphite used in brake linings, foundries, lubricants, and steelmaking, respectively. The natural graphite consumption data in table 2 include mixtures of natural and synthetic graphite in the amorphous graphite category, and this reported consumption data may include company stocks from previous years. Consequently, the table 2 consumption numbers are different from the computed apparent consumption numbers given in table 1. Consumption of crystalline grade decreased in 2009 by 16% to 16,900 t from 20,200 t in 2008. Consumption of amorphous grade decreased by 22% to 23,100 t in 2009 from 29,600 t in 2008. Brake linings, refractories, and steelmaking were the three industries that dominated U.S. natural graphite use. Brake linings, foundries, lubricants, and steelmaking accounted for 74% of natural graphite consumption. The production of batteries and pencils together made up another 3% of consumption. The refractories industry was the leading consumer of crystalline flake graphite, accounting for almost 48% of crystalline flake graphite used in 2009.

Graphite has properties of both metals and nonmetals, which makes it suitable for many industrial applications. The metallic properties include electrical and thermal conductivity. The nonmetallic properties include high-thermal resistance, inertness, and lubricity. The combination of conductivity and high-thermal stability allows graphite to be used in many applications, such as in batteries, fuel cells, and refractories. Graphite's lubricity and thermal conductivity make it an excellent material for high-temperature applications because it provides effective lubrication at a friction interface while furnishing a thermally conductive matrix to remove heat from the same interface. Electrical conductivity and lubricity allow its use as the primary material in the manufacture of brushes for electric motors. A graphite brush effectively transfers electric current to a rotating armature while the natural lubricity of the brush minimizes frictional wear. Today's advanced technology products, such as friction materials and battery and fuel cells, require high-purity graphite. Natural graphite is purified to 99.9% carbon content for use in battery applications.

Graphite is made up of parallel sheets of carbon atoms in a hexagonal arrangement. It is possible to insert other atoms between the sheets, a process that is called intercalation. The insertion of other atoms makes dramatic changes in the properties of graphite. Lithium ions can be inserted to create graphite anodes for lithium ion batteries. Graphite can be intercalated with sulfuric and nitric acids to produce expanded graphite from which foils are formed that are used in seals, gaskets, and fuel cells (Hawley, 2001).

Refractory applications of graphite included carbon-bonded brick, castable ramming, and gunning mixtures. Carbon-magnesite brick has applications in high-temperature corrosive environments, such as iron blast furnaces, ladles, and steel furnaces. Carbon-alumina linings are principally used in continuous steel-casting operations. Alumina- and magnesite-carbon brick requires a particle size of 100 mesh and a purity of 95% to 99% graphite.

Crystalline flake graphite accounted for about 42% of natural graphite usage in the United States. It was consumed mainly in batteries and refractories. Amorphous graphite was mainly used in brake linings, foundries, refractories, steelmaking, and other applications where additions of graphite improve the process or the end product. Lump graphite finds appropriate uses in a number of areas, such as steelmaking, depending on purity and particle size.

Synthetic graphite is used in more applications in North America than natural graphite and accounts for a significant share of the graphite market. The main market for high-purity synthetic graphite is as a carbon raiser additive in iron and steel. This market consumes a significant portion of the synthetic graphite. Other significant uses of all types of graphite are in the manufacture of catalyst supports; low-current, long-life batteries; porosity-enhancing inert fillers; powder metallurgy; rubber; solid carbon shapes; static and dynamic seals; steel; and valve and stem packing. The use of graphite in low-current batteries is gradually giving way to carbon black, which is more economical.

Graphite is used to manufacture antistatic plastics, conductive plastics and rubbers, electromagnetic interference shielding, electrostatic paint and powder coatings, high-voltage power cable conductive shields, membrane switches and resistors, semiconductive cable compounds, and electrostatic paint and powder coatings (George C. Hawley, President, George C. Hawley and Associates, written commun., January 16, 2004).

Prices

In January and February of 2009, graphite prices fell owing to decreases in demand from the U.S. automobile and construction industry sectors (Industrial Minerals, 2009a). During March and April, prices were unchanged as the graphite market remained constant, with ongoing weak demand (Industrial Minerals, 2009d). In the end of May and during June, prices started edging up owing to firm freight rates combined with a weakening U.S. dollar (Industrial Minerals, 2009c). Natural graphite prices continued a slow increase during the second half of 2009 for most types (Industrial Minerals, 2009e).

Prices for crystalline and crystalline flake graphite concentrates ranged from $550 to $1,350 per metric ton; prices for amorphous powder averaged $430 per ton (table 4). The average unit value of all U.S. natural graphite exports decreased by slightly to $1,900 per ton in 2009 from $1,960 per ton in 2008. Ash and carbon content, crystal and flake size, and size distribution affect the price of graphite. The European port price of synthetic graphite in 2009 ranged from $6,200 to $19,000 per ton. The average unit value of synthetic graphite exports increased slightly to $3,100 per ton in 2009 from $3,040 per ton in 2008 (table 5).

Foreign Trade

Total graphite exports decreased by 26% in tonnage to 46,400 t valued at $130 million in 2009 from 62,800 t valued at $182 million in 2008 owing to a 43% increase and a 36% decrease in natural and synthetic graphite exports, respectively. Total graphite export tonnage was 25% natural graphite and 75% synthetic graphite (table 5). Total natural graphite imports decreased by 43% in tonnage to 33,100 t in 2009 from 58,300 t in 2008, and the value decreased by 38% to $29.7 million in 2009 from $48.1 million in 2008 (table 6). Principal import sources of natural graphite were, in descending order of tonnage, China, Mexico, Canada, Brazil, and Madagascar, which combined, accounted for 98% of the tonnage and 90% of the value of total imports. Mexico provided all the amorphous graphite, and Sri Lanka provided all the lump and chippy dust variety. China and Canada were, in descending order of tonnage, the major suppliers of crystalline flake and flake dust graphite. A number of other producing nations supplied several other natural types and grades of graphite to the United States; among the most notable were Brazil and Canada.

World Review

World production of natural graphite decreased slightly in 2009 to an estimated 1.09 million metric tons (Mt) compared with 1.12 Mt in 2008. China maintained its position as the world's leading graphite producer, with 800,000 t. India was the second ranked graphite producer, with 130,000 t, followed by Brazil, North Korea, and Canada, in decreasing order of tonnage produced. These five countries accounted for 97% of world production, and China alone accounted for about 73% (table 8).

During the last half of 2008, global demand for graphite started weakening as the global economy slipped into a recession. Graphite demand continued to weaken until a bottom was reached in June 2009. Since June, market conditions improved somewhat and were not expected to get worse, but at yearend 2009, graphite demand was still slow. These market conditions were because of the recession's effects in the refractory and metallurgical sectors, in which graphite is widely used (Industrial Minerals, 2009b).

Outlook

Worldwide demand for graphite is expected to increase slowly as the world's economy comes out of recession.

An increasing trend of collaboration between Far Eastern and Western graphite producers is taking place in the graphite industry. These collaborations combine superior management, processing, and packaging techniques of Western companies with China's production power located in and adjacent to the largest markets. China offers the optimum cost-location balance. China has serious logistics challenges, though, such as freight issues and shipping problems, rising container rates, Chinese-Government-prioritized internal transportation, possible renewal of export taxes, and licensing law issues. Despite these challenges, the Chinese graphite industry was thriving and is expected to continue increasing (Moores, 2007).

Refractory use trends for graphite closely follow events in the steel industry because graphite is used to manufacture refractory brick for lining iron and steel furnace. The ability to refine and modify graphite is expected to be the key to future growth in the graphite industry. Refining techniques have enabled the use of improved graphite in electronics, foils, friction materials, and lubrication applications (Hand, 1997). Graphite "freeze" refractories are being developed and tested as an alternative to magnesia refractories for ilmenite smelting by U.S.-based GrafTech International Holdings Inc. This technology utilizes a furnace lining of thermally conductive graphite and carbon to lower the temperature and remove the heat from the furnace lining. Once the temperature drops below the melting point of the molten material in the furnace, a protective slag layer called a "skull" is caused to freeze onto the hot face of the refractory lining. Once the slag skull has formed, it extends the life of the lining by insulating the refractories from chemical attacks and thermal shocks (Industrial Minerals, 2009f). Graphite-based refractories also are used as continuous casting ware, usually in the form of nozzles to guide molten steel from ladle to mold. Brake linings and other friction materials are expected to steadily use more natural graphite as new automobile production continues to increase and more replacement parts are required for the increasing number of vehicles. Natural graphite (amorphous and fine flake) is used as a substitute for asbestos in brake linings for vehicles heavier than cars and light trucks. Flexible graphite products, such as grafoil (a thin graphite cloth), are expected to be the fastest growing market but are expected to use small amounts of natural graphite compared with major end-use markets, such as brake linings and refractories. Products produced by advanced refining technology in the next few years, despite a weak refractory market and competitive pricing from Chinese material, could increase profitability in the U.S. graphite industry.

There is a need to double the world's present flake graphite production to satisfy the forecast increased lithium-ion battery demand, particularly in automobiles. Synthetic graphite may offer the most promise for filling that demand (Industrial Minerals, 2009g; 2010). The expected increase in manufacture and sales of hybrid and electric vehicles is likely to increase demand for high-purity graphite in fuel-cell and battery applications. Fuel cells are a potential high-growth, large-volume graphite (natural and synthetic) end use but are currently a very small part of consumption. High volumes of graphite are not expected to be consumed in this end use for many years but may be used in the longer term (Taylor, 2006, p. 517).

Global demand for graphite used in batteries is expected to continue increasing and will be spread between two main consuming sectors—alkaline batteries and lithium-ion batteries. Synthetic and natural graphite are used in these batteries. In alkaline batteries, graphite is the conductive material in the cathode. Until recently, synthetic graphite was predominantly used in these batteries. With the advent of new purification techniques and more efficient processing methods, it has become possible to improve the conductivity of most natural graphite to the point where it can be used in batteries. The decision whether to use synthetic or natural graphite will be based on performance and price. The growth of the lithium-ion battery market could have a more dramatic effect on the graphite market as the demand for mobile energy storage systems rises.

There is a common industry trend toward higher purity and consistency in specifications for some specialized and high-tech applications. The trend to produce higher purity graphite using thermal processing and acid leaching techniques continues. High-purity graphite has applications in advanced carbon graphite composites.

The markets for graphite used in rubber and plastics (including Styrofoam coatings) are growing, and continued growth is expected. The U.S. market for graphite in pencils has almost disappeared; pencil "leads" now are imported directly from China (Taylor, 2006, p. 517). These markets, however, use little graphite and are not expected to have a significant impact on future consumption.

A U.S. company based in California was developing a technology that turns carbon dioxide emissions into high-purity synthetic graphite. With the world's industrialized nations pledging to reduce their carbon dioxide emissions by 50% by 2050, this technology could become a promising new synthetic graphite source while helping industrialized nations reach their target goal (Industrial Minerals, 2009h).

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TABLE 1

SALIENT NATURAL GRAPHITE STATISTICS[1]

		2005	2006	2007	2008	2009
United States:						
Apparent consumption[2]	metric tons	42,400	30,400	42,900	50,300	21,700
Exports:						
Quantity	do.	22,100	22,200	15,700	7,950	11,400
Value	thousands	$15,900	$16,000	$19,100	$15,600	$21,600
Imports for consumption:						
Quantity	metric tons	64,500	52,600	58,600	58,300	33,100
Value	thousands	$34,700	$29,100	$37,300	$48,100	$29,700
World, production	metric tons	1,030,000	1,020,000	1,110,000 [r]	1,120,000	1,090,000 [e]

[e] Estimated. [r] Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits.

[2] Domestic production plus imports minus exports.

TABLE 2
U.S. CONSUMPTION OF NATURAL GRAPHITE, BY END USE[1]

	Crystalline		Amorphous[2]		Total	
End use	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2008:						
Batteries	W	W	--	--	W	W
Brake linings	515	$2,260	3,070	W	3,590	W
Carbon products[3]	266	693	W	W	W	W
Crucibles, retorts, stoppers, sleeves, nozzles	W	W	W	W	W	W
Foundries[4]	W	W	3,600	$13,100	W	W
Lubricants[5]	844	2,910	W	W	W	W
Pencils	W	W	W	W	W	W
Powdered metals	561	1,770	4	8	565	$1,780
Refractories	7,210	6,280	W	W	W	W
Rubber	24	W	W	W	W	W
Steelmaking	W	W	W	W	W	W
Other[6]	8,830	12,900	3,670	21,600	12,500	34,500
Total	20,200	30,900	29,600	125,000	49,800	156,000
2009:						
Batteries	W	W	--	--	W	W
Brake linings	376	$1,560	2,810	W	3,190	W
Carbon products[3]	257	644	W	W	W	W
Crucibles, retorts, stoppers, sleeves, nozzles	W	W	W	W	W	W
Foundries[4]	W	W	1,420	6,490	W	W
Lubricants[5]	684	2,120	W	W	W	W
Pencils	W	W	W	W	W	W
Powdered metals	420	1,270	2	5	423	1,280
Refractories	8,060	6,230	W	W	W	W
Rubber	29	W	W	W	W	W
Steelmaking	W	W	W	W	W	W
Other[6]	5,590	7,950	2,210	13,200	7,800	21,100
Total	16,900	23,300	23,100	95,300	40,000	119,000

W Withheld to avoid disclosing company proprietary data; included in "Total." -- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Includes mixtures of natural and manufactured graphite.

[3] Includes bearings and carbon brushes.

[4] Includes foundries (other) and foundry facings.

[5] Includes ammunition and packings.

[6] Includes antiknock and other compounds, drilling mud, electrical/electronic devices, industrial diamonds, magnetic tape, mechanical products, paints and polishes, small packages, soldering/welding, and other end-use categories.

TABLE 3

SHIPMENTS OF SYNTHETIC GRAPHITE BY U.S. COMPANIES, BY END USE[1]

End use	Quantity (metric tons)	Value (thousands)
2008:		
Anodes	W	W
Cloth and fibers (low modulus)	W	$211,000
Crucibles and vessels, refractories	W	W
Electric motor brushes and machined shapes	W	W
Electrodes	134,000	W
High-modulus fibers	5,720	168,000
Unmachined graphite shapes	10,800	118,000
Synthetic graphite powder and scrap[2]	W	W
Other	W	W
Total	196,000	1,050,000
2009:		
Anodes	W	W
Cloth and fibers (low modulus)	W	165,000
Crucibles and vessels, refractories	W	W
Electric motor brushes and machined shapes	W	W
Electrodes	80,900	W
High-modulus fibers	W	W
Unmachined graphite shapes	8,680	91,300
Synthetic graphite powder and scrap[2]	W	W
Other	W	W
Total	118,000	998,000

W Withheld to avoid disclosing company proprietary data; included in "Total."

[1] Data are rounded to no more than three significant digits.

[2] Includes lubricants (alone/in greases), steelmaking carbon raisers, additives in metallurgy, and other powder data.

TABLE 4

REPRESENTATIVE YEAREND GRAPHITE PRICES[1]

(Dollars per metric ton)

Type	2008	2009
Crystalline large, 94% to 97% carbon, +80 mesh	900–1,000	1,100–1,350
Crystalline large, 90% carbon, +80 mesh	100–800	700–800
Crystalline medium, 94% to 97% carbon, +100-80 mesh	800–900	880–1,150
Crystalline medium, 90% carbon, +100-80 mesh	680–780	650–750
Crystalline medium, 85% to 87% carbon, +100-80 mesh	670–770	650–750
Crystalline fine, 94% to 97% carbon, +100 mesh	600–700	620–1,000
Crystalline fine, 90% carbon, -100 mesh	550–650	550–600
Amorphous powder, 80% to 85% carbon	460	430
Synthetic 99.95% carbon[2]	5,550–17,900	6,200–19,000

[1] Prices are normally cost, insurance, and freight main European port.

[2] Swiss border for 2008 and European port for 2009.

Sources: Industrial Minerals, no. 495, December 2008, p. 88; no. 507, December 2009, p. 68, 69.

TABLE 5

U.S. EXPORTS OF NATURAL AND ARTIFICIAL GRAPHITE, BY COUNTRY[1, 2]

	Natural[3]		Artificial[4]		Total	
Country	Quantity (metric tons)	Value[5] (thousands)	Quantity (metric tons)	Value[5] (thousands)	Quantity (metric tons)	Value[5] (thousands)
2008:						
Canada	1,500	$1,130	8,330	$13,500	9,830	$14,600
China	259	323	6,100	22,500	6,360	22,700
France	20	189	5,130	31,900	5,150	32,100
Germany	125	441	2,010	5,030	2,140	5,470
Hong Kong	3	13	156	486	159	498
Italy	269	447	1,220	4,770	1,490	5,220
Japan	727	1,360	3,290	16,100	4,020	17,500
Korea, Republic of	149	1,330	2,830	10,500	2,980	11,800
Mexico	1,120	1,130	6,040	6,630	7,160	7,760
Netherlands	47	72	596	2,180	642	2,250
Taiwan	305	478	2,170	6,280	2,470	6,760
United Kingdom	379	2,100	1,480	3,410	1,860	5,510
Other	3,060	6,570	15,500	43,100	18,600	49,900
Total	7,950	15,600	54,900	166,000	62,800	182,000
2009:						
Canada	1,070	961	3,230	7,820	4,300	8,780
China	1,790	3,210	2,460	8,860	4,250	12,100
France	11	17	3,630	19,000	3,640	19,000
Germany	65	170	1,300	3,360	1,370	3,530
Hong Kong	25	97	125	362	150	460
Italy	100	164	1,080	5,400	1,180	5,570
Japan	473	1,070	1,700	9,970	2,170	11,000
Korea, Republic of	4,490	7,250	1,970	6,400	6,460	13,600
Mexico	1,080	1,290	4,820	6,670	5,910	7,960
Netherlands	28	101	74	151	102	252
Taiwan	85	281	1,590	6,030	1,670	6,310
United Kingdom	265	2,850	657	1,830	922	4,680
Other	1,900	4,160	12,400	32,800	14,300	36,900
Total	11,400	21,600	35,000	109,000	46,400	130,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Numerous countries for which data were reported have been combined in "Other."

[3] Amorphous, crystalline flake, lump and chip, and natural, not elsewhere classified. The applicable Harmonized Tariff Schedule of the United States (HTS) nomenclatures are "Natural graphite in powder or in flakes" and "Other," codes 2504.10.0000 and 2504.90.0000.

[4] Includes data from the applicable HTS nomenclatures "Artificial graphite" and "Colloidal or semicolloidal graphite," codes 3801.10.0000 and 3801.20.0000.

[5] Values are free alongside ship.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF NATURAL GRAPHITE, BY COUNTRY[1, 2]

Country	Crystalline flake and flake dust		Lump and chippy dust		Other natural crude; high-purity; expandable		Amorphous		Total	
	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)
2008:										
Brazil	2,800	$3,600	--	--	26	$46	--	--	2,820	$3,640
Canada	10,900	8,890	--	--	1,770	7,570	--	--	12,700	16,500
China	27,900	18,800	--	--	--	--	--	--	27,900	18,800
Germany	--	--	--	--	127	1,000	--	--	127	1,000
Guyana	--	--	--	--	--	--	1,380	$92	1,380	92
Japan	--	--	--	--	140	1,500	--	--	140	1,500
Madagascar	799	653	--	--	--	--	--	--	799	653
Mexico	--	--	--	--	--	--	11,500	2,510	11,500	2,510
Sri Lanka	--	--	523	$1,330	--	--	--	--	523	1,330
United Kingdom	--	--	--	--	211	914	--	--	211	914
Other[4]	18	17	--	--	107	1,110	43	8	168	1,140
Total	42,500	32,000	523	1,330	2,380	12,100	12,900	2,610	58,300	48,100
2009:										
Brazil	989	1,170	--	--	1,860	3,030	--	--	2,850	4,200
Canada	2,150	1,860	--	--	4,180	8,540	--	--	6,330	10,400
China	15,100	9,430	--	--	--	--	--	--	15,100	9,430
Germany	--	--	--	--	72	205	--	--	72	205
Guyana	--	--	--	--	--	--	--	--	--	--
Japan	--	--	--	--	105	1,250	--	--	105	1,250
Madagascar	899	839	--	--	--	--	--	--	899	839
Mexico	--	--	--	--	--	--	7,310	1,820	7,310	1,820
Sri Lanka	--	--	134	189	--	--	--	--	134	189
United Kingdom	--	--	--	--	173	872	--	--	173	872
Other[4]	--	--	--	--	75	470	--	--	75	470
Total	19,200	13,300	134	189	6,460	14,400	7,310	1,820	33,100	29,700

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The information framework from which data for this material were derived originated from Harmonized Tariff Schedule of the U.S. base data.

[3] Customs values.

[4] Includes Austria (2008), Belgium (2008), Czech Republic (2008), France (2009), India (2008), Italy, Japan (2009), Korea, Republic of, Netherlands (2008), Russia (2008), Singapore (2009), Sweden (2008), Switzerland, Taiwan (2009), and Ukraine (2008).

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 7

U.S. IMPORTS FOR CONSUMPTION OF GRAPHITE ELECTRODES, BY COUNTRY[1, 2]

Country	Quantity (metric tons)	Value[3] (thousands)
2008:		
Canada	9,640	$45,100
China	29,000	61,200
Germany	2,020	13,600
India	1,010	2,870
Italy	129	265
Japan	18,100	87,200
Mexico	23,800	62,400
Poland	4,410	10,900
Russia	7,350	12,400
Ukraine	961	2,570
Other[4]	1,650	4,630
Total	98,100	303,000
2009:		
Canada	5,160	30,700
China	12,500	34,100
Germany	1,120	6,750
India	7,410	21,600
Japan	5,980	40,900
Mexico	8,980	24,000
Poland	1,810	7,910
Russia	5,560	15,300
Ukraine	482	1,420
United Kingdom	851	4,930
Other[4]	784	2,500
Total	50,600	190,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The applicable Harmonized Tariff Schedule of the United States (HTS) nomenclature is "Electric furnace electrodes," code 8545.11.0000.

[3] Customs values.

[4] Includes data for countries that ship less than 1,000 metric tons per year to the United States.

Source: U.S. Census Bureau.

TABLE 8
GRAPHITE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2005	2006	2007	2008	2009[e]
Brazil, marketable	77,494 [r, 3]	76,194 [3]	77,163 [3]	76,200 [r, 3]	76,200
Canada	28,000	28,000	28,000	27,000	25,000
China	720,000	720,000	800,000	810,000	800,000
Czech Republic	3,000	5,000	3,000	3,000	--
Germany, marketable	2,638 [3]	--	--	--	--
India, run-of-mine[4]	130,000	120,000	130,000	140,000	130,000
Korea, North	32,000	30,000	30,000	30,000	30,000
Korea, Republic of	39 [3]	68 [3]	52 [3]	73 [r, 3]	70
Madagascar	6,400 [3]	4,857 [3]	5,000	5,000 [e]	5,000
Mexico, amorphous	12,357 [3]	12,500	12,500	7,229 [r, 3]	5,011 [p, 3]
Norway	2,300	2,300	2,000	2,000	2,000
Romania	500	--	--	--	--
Sri Lanka	3,000	5,756 [r, 3]	9,593 [r, 3]	10,000 [r]	11,000
Sweden	800	800	800	800	800
Turkey, run-of-mine[5]	100	300	400	400	400
Ukraine	10,400 [r]	5,800 [r]	5,800 [r]	5,800 [r]	5,800
Uzbekistan	60	60	60	60	60
Zimbabwe	4,298 [3]	6,588 [3]	6,000 [r]	5,000 [r]	2,500
Total	1,030,000	1,020,000	1,110,000 [r]	1,120,000	1,090,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 5, 2010.

[3] Reported figure.

[4] Indian marketable production is 10% to 20% of run-of-mine production.

[5] Turkish marketable production averages approximately 5% of run-of-mine production. Almost all is for domestic consumption.

GYPSUM

By Robert D. Crangle, Jr.

Domestic survey data and tables were prepared by Paula R. Neely, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2009, the United States ranked fourth worldwide in the production of crude gypsum, with 10.4 million metric tons (Mt) of production and a reported value of $77.4 million. China was the world's leading producer and consumer of gypsum, with estimated production of 45 Mt of crude gypsum. As a result of the continued economic recession in the United States, especially in the residential construction sector, 2009 production tonnage decreased by approximately 15% from that of 2008, with a corresponding decrease in value of 15% (table 1). Calcined gypsum production decreased by 23% to 13.8 Mt in 2009 compared with 17.9 Mt produced in 2008.

The sale of synthetic gypsum decreased by 16% to 8.1 Mt in 2009 from 9.7 Mt in 2008. The long-term use of synthetic gypsum from flue gas desulfurization (FGD) will likely continue to increase as more coal-fired electric powerplants convert their desulfurization processes to produce marketable gypsum. Most coal-burning powerplants in the United States are required by the U.S. Environmental Protection Agency to install sulfur dioxide scrubbing systems. This created a significant source of gypsum, at a lower price than the cost of its mined counterpart, which led to the construction of wallboard production facilities adjacent to coal-fired powerplants.

Domestic Data Coverage

Gypsum industry data for this report are collected by the U.S. Geological Survey (USGS) from semiannual and annual surveys of gypsum operations and from monthly data provided by the Gypsum Association. In 2009, the USGS annual survey canvassed 112 gypsum production operations that accounted for all known domestic output of crude, calcined, and byproduct gypsum. Data were available for all of the operations through this survey, the Gypsum Association, the American Coal Ash Association, or other Federal and State agencies. Some production was estimated on the basis of employment records published by the Mine Safety and Health Administration (MSHA).

Production

The United States was the fourth leading producer of gypsum in 2009, accounting for 6% of reported global output (table 8). During 2009, crude gypsum in the United States was mined by 30 companies at 48 mines in 16 States (table 2). The leading crude gypsum-producing States were, in descending order, Oklahoma, Iowa, Texas, Indiana, and Nevada, which together accounted for 67% of total domestic output.

The U.S. gypsum industry consisted primarily of a few large, vertically integrated companies that mined gypsum and manufactured wallboard, plaster, and other gypsum products. Companies with the most mines were USG Corp. (USG) with nine mines; National Gypsum Co. (NGC) with seven mines; Georgia Pacific LLC (GP) with six mines; Harrison Gypsum Co. with three mines; CertainTeed Corp. with four mines; and Temple Inland Inc. (TI) with three mines. For 2009, these eight companies produced 71% of the total U.S. crude gypsum.

During 2009, gypsum was calcined (partially dehydrated by heating) at 31 plants operated by 8 companies in 17 States, principally to produce feedstock for wallboard and plaster manufacturing plants (table 3). The leading gypsum calcining States in 2009 were, in descending order, Texas, Pennsylvania, Indiana, Arkansas, and Kansas (table 3). These 5 States had 14 plants that produced approximately 8.9 Mt of calcined gypsum and together accounted for about 65% of national output. In 2009, domestic output of calcined gypsum decreased by 23% to 13.8 Mt valued at more than $486 million (table 1).

In addition to mined gypsum production, synthetic gypsum was generated as a byproduct of various industrial processes. The primary source of synthetic gypsum was FGD from coal-fired electric powerplants. Smaller amounts of synthetic gypsum were derived as a byproduct of chemical processes, such as acid neutralization processes, citric acid production, sugar production from sugar beets, and titanium dioxide production. Synthetic gypsum was used as a substitute for mined gypsum, principally for wallboard manufacturing, cement production, and agricultural purposes, in descending order of importance.

Synthetic gypsum producers sold 8.12 Mt of synthetic gypsum from their FGD systems during 2009, with an estimated value of $12.2 million. Of the total synthetic gypsum sold and used, 81% was used for wallboard production, 7% was used in cement and concrete manufacture, 5% for structural fills or embankments, 3% for agricultural, and the remaining amount for other miscellaneous applications. Approximately 50% of synthetic gypsum produced in 2009 was neither sold, nor used, and in most cases was landfilled (American Coal Ash Association, 2011).

For 2009, gypsum-derived products, including agricultural products, cement, plasters, and wallboard totaled 14.0 Mt with a value of $1.92 billion. This represented a production decrease of 28% from the 19.6 Mt produced in 2008, and a 26% decrease in value from $2.6 billion (table 4).

During 2009, eight companies manufactured gypsum wallboard products at 31 plants in the United States. Wallboard product shipments were approximately 1.83 billion square meters (17.0 billion square feet), a decrease of about 27% compared with those of 2008 (table 5).

The years between 2003 and 2006 marked a period of rapid expansion in the wallboard industry. American Gypsum, BPB, Lafarge North America Inc. (Lafarge NA), National Gypsum, and USG expanded their existing wallboard operations or opened new ones during this time, increasing their wallboard production capacities by more than 1 billion square feet. The decline in the U.S. housing market began in 2007 and continued through 2009. This resulted in flat and declining sales for most gypsum producers, coupled with layoffs and the idling of wallboard production plants (Crangle, 2011).

Consumption

In 2009, U.S. apparent domestic gypsum consumption was more than 22.6 Mt, a 25% decrease compared with that of 2008. Domestic sources (mined crude plus an estimated 8.12 Mt of synthetic gypsum produced) met approximately 82% of domestic consumption requirements; imports, totaling 4.22 Mt, satisfied the remaining need. In 2009, approximately 36% of the gypsum consumed in the United States came from synthetic sources, slightly more than that which was reported in 2008. An industry-wide shift toward the use of more synthetic gypsum continued in 2009. This was largely the result of the lower costs associated with the purchase and transportation of FGD gypsum, which is often available near the same urban centers where wallboard production facilities are located.

Gypsum output is categorized as either calcined or uncalcined (table 4). Calcined gypsum was produced domestically from crude gypsum to manufacture wallboard and plaster products. Uncalcined gypsum, used for portland cement production and agriculture, accounted for virtually all remaining consumption during the year. Miscellaneous uses, such as athletic field markings, accounted for only a fraction of 1% of consumption.

In 2009, about 88% of the calcined gypsum used to manufacture wallboard was consumed in the production of regular ½-inch gypsum board (table 5). This product represented 42% of total calcined gypsum consumption. Type X gypsum board, so named because of extra fire retardation qualities, consumed 38% of calcined gypsum. Other regular gypsum board, from ¼- to 1-inch thick, consumed 6% of the total. Other wallboard, including lath, mobile-home wallboard, predecorated wallboard, sheathing, veneer base, and water- and moisture-resistant wallboard, composed most of the balance. Metropolitan areas in the South Atlantic, East North Central, Middle Atlantic, West South Central, and West North Central (in decreasing order) were the leading sales areas for gypsum wallboard products.

As a result of the economic downturn and the associated reduction in the construction industry's demand for concrete, uncalcined gypsum consumed in the United States decreased by 36% in 2009 to 1.34 Mt. About 992,000 t, or 74%, of the uncalcined gypsum consumed in the United States was for Portland cement production (table 4). Gypsum is added to cement to retard its setting time and makes up about 2% to 4% by weight of cement output (Roskill Information Services Ltd., 2009, p. 320). Most of the remainder of the uncalcined gypsum consumed, about 352,000 metric tons (t), was used primarily for agricultural purposes. Agricultural use of gypsum decreased by 43% from that of 2008. Finely ground gypsum rock was used in agriculture and other industries to neutralize acidic soils, to improve soil permeability, to add nutrients, to stabilize slopes, and to provide catalytic support for maximum fertilizer benefits. Small amounts of high-purity gypsum are also used in a wide range of industrial applications, including the production of foods, glass, paper, and pharmaceuticals.

Recycling

Gypsum waste generated by the wallboard manufacturing process can be recycled. The gypsum core and paper covering are separated, then reinjected with new material into the manufacturing stream.

Several million tons of gypsum waste is generated every year by building demolition, wallboard installation, and wallboard manufacturing. Because labor expenses are higher than wallboard prices, construction costs are lowered when full pieces of uncut wallboard are used in place of multiple, smaller remnants. As a result, between 10% and 12% of the wallboard used in new construction and renovation is discarded as scrap. Only a small portion of this waste has been recycled. In 2006, two wallboard manufacturers in the United States began to use recycled material to supplement natural gypsum at plants in New England. As landfill space becomes more scarce, recycling is expected to increase. In addition to recycling scrap in wallboard plants, wallboard scrap may also be ground and used as a soil conditioner.

International gypsum-recycling efforts were more robust. As a result of legislation enacted in November 2008 in the United Kingdom, gypsum-based products are prohibited from being placed in landfills (Global Gypsum Magazine, 2009a, c). On a lesser scale, similar efforts were observed in India, where waste gypsum was used to manufacture building panels (Global Gypsum Magazine, 2009c).

Wallboard manufacturers and the construction industry have been exploring ways to return scrap wallboard and waste wallboard to plants for recycling. Other potential markets for recycled gypsum include cement production, as a stucco additive, sludge drying, water treatment, grease absorption, and for marking athletic fields. Until costs and legislation associated with landfilling scrap gypsum become more restrictive, recycling will likely continue to remain a low priority within the industry.

Prices

In 2009, the average values (free on board, mine or plant) reported by U.S. producers were $7.44 per metric ton for crude gypsum and $35.28 per ton for calcined gypsum (table 1). The average value for plaster reported by domestic producers during the year was $148 per ton (table 4). The average value of uncalcined gypsum used in agriculture (not including miscellaneous uses) was about $25.95 per ton and that used in cement production was about $15.52 per ton (table 4).

During 2009, prices for gypsum wallboard generally decreased in response to a corresponding decrease in demand. The decline was related to the continuing decline in the housing construction sector, on which the gypsum industry is heavily dependent. The combined average price of ½-inch wallboard for 20 major U.S. metropolitan cities in 2009 was $260.96 per 100 square meters ($242.44 per 1,000 square feet). From January 2009 to January 2010, prices for ½-inch wallboard and Type X wallboard decreased by 10% and 8%, respectively, in 20 major

U.S. metropolitan cities (Engineering News-Record, 2009, 2010).

Average ½-inch wallboard prices during 2009 were lowest in St. Louis, MO, ($185 per 100 square meters or $172 per 1,000 square feet), followed by Detroit, MI, ($187 per 100 square meters or $174 per 1,000 square feet), and Cleveland, OH, ($194 per 100 square meters or $180 per 1,000 square feet). The highest average wallboard prices in 2009 were in Boston, MA, ($405 per 100 square meters or $377 per 1,000 square feet), followed by Philadelphia, PA, ($311 per 100 square meters or $289 per 1,000 square feet) and San Francisco, CA, ($309 per 100 square meters or $287 per 1,000 square feet).

Foreign Trade

In 2009, the United States led the world in international trade in gypsum and gypsum products (tables 6, 7). The United States imported crude gypsum from 11 countries and exported gypsum and gypsum products to 97 countries and territories, although only a small quantity of crude gypsum and other gypsum products were exported by the United States in 2009, most of which went to Canada.

Imports of crude gypsum in 2009 decreased by 42% from those of 2008 and accounted for 19% of apparent consumption. Much of this import dependence can be attributed to the lack of adequate domestic gypsum resources near large east coast and west coast wallboard markets. Canada and Mexico accounted for 96% of imported gypsum, while imports from Spain supplied most of the remainder. Imports from Brazil, China, France, Germany, South Korea, Singapore, Sweden, and the United Kingdom were negligible (table 6). The majority of imports from Canada went to east coast plants, while Mexican sources chiefly served the west coast. Foreign subsidiaries of U.S. gypsum companies produced much of the gypsum that was imported for their respective U.S.-based wallboard plants. The majority of the crude gypsum imported by the United States from Mexico was produced by Compania Minera Caopas, S.A. de C.V. and Compania Occidental Mexicana S.A. de C.V. in Baja California Sur, both of which operate mines on the Baja California Peninsula (Compania Occidental Mexicana S.A. de C.V., 2005; Compania Minera Caopas, S.A. de C.V., 2010). Almost all gypsum imported from Canada came from Nova Scotia. The completion of large wallboard manufacturing plants near powerplants along the east coast may reduce gypsum imports in the future.

Although wallboard exports appeared to increase by nearly 579% in 2009, totaling about 73.9 million square meters (796 million square feet) valued at $120 million, an adjustment by the U.S. Census Bureau in the method for calculation of 2009 wallboard exports to Canada resulted in the large year-over-year increase. Consequently, this increase should not be interpreted as an actual rise in exports. The majority of board exports went to Canada in 2009, which accounted for 93%, followed by 63 other countries, each of which accounted for a negligible amount. Reflecting a significant decrease in demand owing to the decline in the U.S. housing sector, wallboard imports decreased by 42% in 2009, totaled 50 million square meters (535 million square feet), and were valued at $30.3 million.

World Industry Structure

Global crude gypsum production in 2009 was estimated to be 149 Mt, representing a decrease of 5% compared with that of 2008, when production totaled 157 Mt (table 1). In 2009, 87 countries produced gypsum, 10 of which accounted for 74% of the total world production (table 8). An estimated 250 million metric tons per year of synthetic gypsum (mostly phosphogypsum) was generated worldwide (Roskill Information Services Ltd., 2009, p. 22). Much of the synthetic production, however, was disposed of rather than used. China was the leading producer of crude gypsum in 2009 with an estimated 45 Mt, followed by Iran with 13.0 Mt, Spain with 11.5 Mt, the United States with 10.4 Mt, Thailand with 8.5 Mt, Mexico and Japan with 5.8 Mt each, and Italy with 4.1 Mt. Given the expansion in China's economy and its respective construction and infrastructure demands, China will likely continue to be the world's leading gypsum producer for the near future. North American production accounted for more than 13% of total crude gypsum production. Although the use of gypsum wallboard increased worldwide, only industrialized nations used gypsum primarily for wallboard products. In developing countries, especially in Asia and the Middle East, most gypsum was used in the production of cement or plaster products. World production may have been underestimated, because output by some foreign gypsum producers was used to manufacture products onsite, which may not have been reported. Additionally, production from small deposits in developing nations was intermittent and in many cases unreported.

Worldwide, the leading use of gypsum is in the manufacture of cement and concrete. In 2008 (the last year worldwide end use was available), cement manufacture accounted for up to 60% of worldwide gypsum consumption, while plaster products, including wallboard, accounted for approximately 30% of all consumption (Roskill Information Services Ltd., 2009, p. 320, 330).

As a low-value, high-bulk commodity drawn from deposits widely distributed throughout the world, gypsum tended to be consumed within the many countries where it was produced. Less than 20% of the world's crude gypsum production was estimated to enter international trade. Only a few countries, such as Canada, Mexico, Spain, and Thailand, were major crude gypsum exporters; of these, Canada and Mexico were significant exporters because of their large deposits in proximity to wallboard markets in the United States. Compared to imports, little crude gypsum was exported from the United States (tables 1, 7).

Estimated world production capacity for gypsum wallboard in 2009 exceeded 17 billion square meters per year (about 183 billion square feet per year) at more than 250 plants worldwide. Approximately 20% of this capacity was in the United States; Asia and Western Europe each accounted for about 20% of capacity.

World Review

Asia.—A significant increase in commercial and residential construction and infrastructure additions and improvements, coupled with a cultural shift toward the use of more gypsum-based products, resulted in increased gypsum consumption. Since 2002, the production of crude gypsum in Asia has increased 2% faster than the rate of economic growth, as the acceptance and use of wallboard and plaster products has increased faster than the region's Gross Domestic Product (GDP) (Roskill Information Services Ltd., 2009, p. 18). In a continuing trend throughout the region, India opened a new load-bearing phosphogypsum panel plant. Panels from this plant were purported to be substitutes for brick and concrete (Global Gypsum Magazine, 2009b).

Europe.—Lafarge Group, a French company, indicated that effects from the global economic downturn led to continued corporate losses in 2009 (Global Gypsum Magazine, 2010a). Lafarge Group operated 76 wallboard plants (33 in Europe) in 29 countries with 8,132 employees and total sales of $2.12 billion (Lafarge Group, 2009, p. 5).

Middle East.—Most countries in the Middle East consume all domestically produced gypsum, with the exception of Iran, which annually exports more than 1 Mt (Roskill Information Services Ltd., 2009, p. 17).

South America.—In 2009, Lafarge operated wallboard plants in Argentina, Brazil, Chile, and Colombia as well as plaster plants in Brazil and Chile (Lafarge, 2009, p. 36–37). Brazilian Gypsum produced approximately 2 Mt of gypsum in 2008, representing 95% of total Brazilian production, with mineral reserves estimated to be 1,200 Mt (Brazilian Gypsum, 2010).

Australia.—Australian housing construction activity decreased by 7% in 2009 to 139,000 new-home starts, a 40-year low, reflecting the global recession that slowed both residential and commercial building activities (Housing Industry Association of Australia, 2011). In response to the economic decline, Boral Ltd., Australia's largest building and construction materials supplier, reported an earnings decrease of 42% (Boral Ltd., 2009, p. 4, 24).

Canada.—In 2009, Canadian production of crude gypsum totaled 3.54 Mt, a 38% decline from that of 2008. About 2.72 Mt, or 77% of Canadian production, was exported to the United States. The sluggish U.S. residential and commercial construction sectors were likely to continue to have a negative impact on the Canadian gypsum industry.

China.—Despite the continued slow global economy, China expected continued growth in wallboard and plaster production in 2010 of 8% to 10% (Roskill Information Services Ltd., 2009, p. 18). The issue of corrosive imported wallboard from China into the United States continued to be a problem. The U.S. Consumer Product Safety Commission received more than 3,000 reports of possible corrosive wallboard from residents in 42 States, the District of Columbia, American Samoa, and Puerto Rico (U.S. Consumer Product Safety Commission, 2009). Only one Chinese wallboard manufacturer, Knauf Plasterboard Tianjin, responded to U.S. litigation regarding complaints of Chinese-manufactured wallboard, acknowledging that some wallboard may emit sulfide gasses. These gasses were suspected to damage copper wiring and plumbing, while also raising human-health concerns (Global Gypsum Magazine, 2010b).

Mexico.—In 2009, gypsum production in Mexico was 5.76 Mt, a 12% increase from that of 2008, the only North American gypsum producer to show an increase. About 1.34 Mt, or 23% of Mexico's 2009 crude gypsum production, was exported to the United States. In 2009, USG Mexico S.A. de C.V., the largest manufacturer of wallboard in Mexico, operated four gypsum quarries and three wallboard manufacturing facilities, which accounted for more than 50% of the country's total market share (USG Corp., 2010, p. 14).

Nigeria.—Changes in Nigerian import regulations allowed the country's cement manufacturer to annually import the estimated 500,000 t of gypsum needed to meet the country's cement demand. Prior to the regulation change, large quantities of imported gypsum were prohibited from being imported, which required the importation of much more expensive bagged cement (Global Gypsum Magazine, 2009a).

Outlook

U.S. demand for gypsum products was expected to stabilize during the next 2 to 3 years as housing starts are expected to remain constant (U.S. Census Bureau, 2010). Because the residential housing market is responsible for approximately 60% of the consumption of gypsum products, a key economic indicator used by the gypsum and wallboard industries is the number of new housing starts, as measured by the issuance of new building permits. Preliminary gypsum production and consumption data for the beginning of 2010 indicated that the amount of gypsum used was likely to remain level.

The availability of FGD gypsum was expected to continue to increase as new scrubbers come online at more coal-fired electric powerplants (U.S. Environmental Protection Agency, 2010). During the next several years, the use of mined gypsum may continue to decline in the United States as greater quantities of synthetic gypsum are used in wallboard manufacturing. Some actual and planned gypsum mine closings have already been attributed to the increased availability of synthetic gypsum. This increased use of synthetic gypsum could accelerate additional mine closings through 2020. This changeover, however, will likely be limited to FGD plants with close proximities to wallboard production facilities, or where new wallboard plants will be constructed adjacent to existing FGD plants. The percentage of synthetic gypsum use may eventually reach an economic equilibrium point. In the long term, as disposal areas fill and the opening of new disposal sites becomes increasingly difficult, power companies may have to calcine, clean, or subsidize the transportation costs associated with synthetic gypsum in order to dispose of excess waste. This may increase the economic viability of using FGD gypsum from powerplants that are presently considered too far from wallboard plants.

Expansion of synthetic gypsum resources will continue in the United States. Forecasts indicate that demand of high calcium limestone, the primary component required to transform sulfur dioxide to synthetic gypsum, in many FGD processes, could increase by about 70% during the next 10 years as existing and new coal-fired powerplants are fitted with FGD scrubbing systems to meet Clean Air Act regulatory requirements (Industrial Minerals, 2008). Approximately 85% of FGD systems are wet scrubbers that use a limestone slurry to capture sulfur dioxide emissions (Industrial Minerals, 2009). The trend toward FGD gypsum as a raw material, at the expense of crude gypsum, is expected to continue as air pollution regulations become more stringent within the United States and throughout the industrialized world.

The U.S. gypsum industry has been moving toward the use of large-capacity wallboard plants supplied from multiple sources, including synthetic gypsum from coal-fired powerplants. These larger wallboard plants have been built in regions of high population and growth, which are the areas of highest consumption. The older, less efficient, and smaller natural (mined) gypsum-fed plants will find it increasingly difficult to compete, and some likely will close. As a response to increased public awareness, the gypsum industry may boost the recycling of scrap gypsum into its raw materials streams. The industry may also increase the use of ecolabels, such as the Scientific Certification System Green Cross, which certifies the presence of recycled and recovered content in each product.

Industry trends indicate significant developments abroad in the coming decade. The pace and magnitude of wallboard plant construction in Asia, particularly China, India, and Thailand, suggest that the continent, with billions of potential consumers, will probably become one of the world's leading gypsum wallboard markets. Elsewhere, wallboard production capacity growth and the recognition of the convenience and economy of wallboard as a building material in Central America, Europe, India, and South America means that wallboard manufacturing may require increased gypsum production in future years. A decline in national and global economic conditions may, however, hamper such growth.

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TABLE 1

SALIENT GYPSUM STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2005	2006	2007	2008	2009
United States:					
Crude:					
Production:					
Quantity	18,700 [r]	18,600 [r]	15,700 [r]	12,300 [r]	10,400
Value	98,000 [r]	107,000 [r]	95,000 [r]	91,200 [r]	77,400
Imports for consumption	11,200	11,400	9,390	7,330	4,220
Synthetic gypsum sales	8,410	8,670	8,370	9,660	8,120
Calcined:					
Production:					
Quantity	24,300 [r]	21,600 [r]	21,700 [r]	17,900 [r]	13,800
Value	756,000 [r]	716,000 [r]	768,000 [r]	674,000 [r]	486,000
Products sold, value	4,750,000 [r]	4,260,000 [r]	3,610,000 [r]	2,500,000 [r]	1,850,000
Exports, value	33,700	36,700	43,600	47,400	37,800
Imports for consumption, value	4,350	5,010	6,700	7,240	6,800
World, production	147,000 [r]	160,000 [r]	166,000 [r]	155,000 [r]	149,000 [e]

[e]Estimated. [r]Revised.

[1]Data are rounded to no more than three significant digits.

TABLE 2

CRUDE GYPSUM MINED IN THE UNITED STATES, BY STATE[1]

	2008			2009		
State	Active mines	Quantity (thousand metric tons)	Value (thousands)	Active mines	Quantity (thousand metric tons)	Value (thousands)
Arizona, New Mexico	6 [r]	738 [r]	$5,500 [r]	6	530	$4,100
Arkansas, Indiana, Kansas, Louisiana	6	3,040	22,600	6	1,840	13,200
California, Nevada, Utah	10 [r]	1,880 [r]	14,000 [r]	11	1,850	13,200
Colorado, South Dakota, Wyoming	4	713	5,300	4	535	3,830
Iowa	6 [r]	1,250 [r]	9,230 [r]	7	1,780	14,800
Michigan	3	603 [r]	4,490 [r]	3	372	3,110
Oklahoma	4 [r]	2,180 [r]	16,200 [r]	5	2,180	15,900
Texas	6 [r]	1,870 [r]	13,900 [r]	6	1,310	9,330
Total	45 [r]	12,300 [r]	91,200 [r]	48	10,400	77,400

[r]Revised.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 3

CALCINED GYPSUM PRODUCED IN THE UNITED STATES, BY STATE[1]

	2008			2009		
State	Active plants	Quantity (thousand metric tons)	Value (thousands)	Active plants	Quantity (thousand metric tons)	Value (thousands)
Arizona, Colorado, Utah, Wyoming	4	850	$31,900	4	655	$23,100
Arkansas, Florida, Texas	8	6,030	226,000	7	3,930	139,000
California, Nevada, Washington	5	1,830	68,700	5	1,220	43,100
Indiana, Michigan, New Hampshire, New Jersey, New York, Pennsylvania	9	6,910	259,000	9	5,430	191,000
Iowa and Kansas	5	2,340	87,800	6	2,540	89,500
Total	31 [r]	17,900 [r]	674,000 [r]	31	13,800	486,000

[r]Revised.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 4
GYPSUM PRODUCTS (MADE FROM DOMESTIC, IMPORTED, AND SYNTHETIC GYPSUM) SOLD OR USED IN THE UNITED STATES, BY USE[1]

(Thousand metric tons and thousand dollars)

Use	2008[r] Quantity	2008[r] Value	2009 Quantity	2009 Value
Uncalcined:				
Portland cement	1,500	24,200	992	15,400
Agriculture and miscellaneous[2]	614	30,500	352	19,500
Total	2,110	54,800	1,340	34,900
Calcined:				
Plasters	102	32,400	83	27,700
Prefabricated products[3]	17,300	2,500,000	12,600	1,850,000
Total	17,400	2,530,000	12,700	1,880,000
Grand total	19,600	2,590,000	14,000	1,920,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes synthetic gypsum.

[3] Includes weight of paper, metal, or other materials and some synthetic gypsum.

TABLE 5
PREFABRICATED GYPSUM PRODUCTS SOLD OR USED IN THE UNITED STATES[1]

Product	2008 Quantity (thousand square feet)	2008 Quantity[2] (thousand metric tons)	2008 Value[r] (thousands)	2009 Quantity (thousand square feet)	2009 Quantity[2] (thousand metric tons)	2009 Value (thousands)
Lath:						
3/8-inch	-- r	-- r	--	--	--	--
1/2-inch	-- r	-- r	--	--	--	--
Other	21,600	18	$2,720	29,900	27	$4,020
Total	21,600 r	18 r	2,720	29,900	27	4,020
Veneer base	288,000 r	214 r	28,500	202,000	147	21,100
Sheathing	596,000 r	433 r	71,700	390,000	283	48,400
Regular gypsumboard:						
3/8-inch	564,000 r	316 r	58,400	467,000	270	46,100
1/2-inch	11,300,000 r	7,370 r	1,060,000	8,360,000	5,360	817,000
5/8-inch	507,000 r	432 r	95,200	329,000	267	58,800
1-inch	88,500 r	71 r	10,600	58,600	51	7,940
Other[3]	484,000 r	270 r	83,100	260,000	170	46,800
Total	13,000,000 r	8,460 r	1,310,000	9,470,000	6,120	977,000
Type X gypsumboard	9,210,000 r	6,780 r	793,000	6,550,000	4,860	561,000
Predecorated wallboard	128,000 r	103 r	50,000	58,700	43	18,800
5/16-inch mobile home board	311,000 r	185 r	32,500	202,000	119	23,700
Water- and moisture-resistant board	1,350,000 r	993 r	198,000	1,140,000	835	174,000
Other	149,000 r	156 r	19,000	213,000	187	26,900
Grand total	25,000,000 r	17,300 r	2,500,000	18,300,000	12,600	1,850,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes weight of paper, metal, or other materials.

[3] Includes 1/4-, 7/16-, and 3/4-inch gypsumboard.

TABLE 6

IMPORTS FOR CONSUMPTION OF CRUDE GYPSUM, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

Country	2008 Quantity	2008 Value	2009 Quantity	2009 Value
Brazil	--	--	(2)	2
Canada[3]	4,740	62,900	2,720	38,500
China	42	307	(2)	17
Dominican Republic	66	2,070	--	--
France	--	--	(2)	8
Germany	--	--	(2)	10
India	(2)	2	--	--
Italy	(2)	27	--	--
Jamaica	19	742	--	--
Japan	(2)	2	--	--
Korea, Republic of	(2)	20	(2)	15
Mexico	1,930	19,500	1,340	12,700
Netherlands	(2)	3	--	--
Singapore	--	--	(2)	2
Spain	524	7,720	164	1,640
Sweden	--	--	(2)	3
United Kingdom	(2)	20	(2)	8
Total	7,330	93,400	4,220	52,900

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

[3] Includes anhydrite.

Source: U.S. Census Bureau.

TABLE 7

U.S. GYPSUM AND GYPSUM PRODUCTS TRADE FOREIGN[1]

(Thousand metric tons and thousand dollars)

Year	Crude[2] Quantity	Crude[2] Value	Plasters[3] Quantity	Plasters[3] Value	Boards[4] Quantity	Boards[4] Value	Other, value[5]	Total, value
Exports:								
2008	149	20,500	135	47,400	98	133,000	55,400	257,000
2009	156	16,000	155	37,800	665	120,000	50,200	224,000
Imports for consumption:								
2008	7,330	93,400	13	7,240	306	50,600	43,400	195,000
2009	4,220	52,900	15	6,800	236	38,500	30,300	128,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Data are for "Gypsum, anhydrite," Harmonized Tariff Schedule of the United States (HTS) code 2520.10.0000.

[3] Data are for "Plasters," HTS code 2520.20.0000.

[4] Data are for "Boards, sheets, panels, tiles, and similar articles, not ornamented—Faced or reinforced with paper or paperboard only," HTS code 6809.11.0000.

[5] Data are for "Boards, sheets, panels, tiles, and similar articles, not ornamented: Other," HTS code 6809.19.0000, and "Other articles," HTS code 6809.90.0000.

Source: U.S. Census Bureau.

TABLE 8
GYPSUM: WORLD PRODUCTION, BY COUNTRY[1,2]

(Thousand metric tons)

Country	2005	2006	2007	2008	2009[e]
Afghanistan[e]	2	2	2	2	2
Algeria	1,460	1,033	1,198	1,672	1,700[3]
Argentina	1,073	1,203	1,227	1,257[r]	1,300
Armenia	44	44	55	46[r]	45[3]
Australia	3,857	4,265	3,896	3,500[e]	3,500
Austria:					
Gypsum	911	936	1,006	1,023	900
Anhydrite	106	135	57	64	50
Total	1,017	1,071	1,064	1,087[r]	950
Azerbaijan	28	35	22	23[e]	22
Bhutan	151	160	165[r]	160[e]	160
Bolivia	(5)	1	4	4[e]	1
Bosnia and Herzegovina	153	132	154	150[r]	150
Brazil[4]	1,582	1,712[r]	1,923[r]	1,923[r]	1,923[p,3]
Bulgaria[4]	188	216	234	230[r,e]	230
Burma	68	69	75[r]	82[r]	98[3]
Canada[4]	9,400	9,036	7,562	5,740	3,540
Chile	661	845	773	774	724[3]
China[e]	32,000	42,000	48,000	46,000	45,000
Colombia	173	186	200	200[e]	190
Croatia	196	170	335[r]	335[r,e]	335
Cuba[e]	(5)	(5)	(5)	(5)	(5)
Cyprus[e]	260	250[3]	250	250	250
Czech Republic	25	16	66	35[e]	13
Dominican Republic	181[r]	161[r]	146[r]	185[r]	175
Ecuador[e]	1[3]	1[3]	2	1	1
Egypt[e,4]	2,000	2,000	3,007[r,3]	2,381[r,3]	2,500
El Salvador[e]	6	6	6	6	6
Eritrea[e]	1	1[3]	1	1	1
Ethiopia[4]	35	39	30[r]	33[r]	33
France[e,4]	4,902[3]	4,800	4,800	2,339[r,3]	2,300
Germany, marketable[4]	1,644	1,771	1,898	2,112[r]	1,898[3]
Greece[e,4]	500	500	500	500	500
Guatemala	350	227	495	127[r]	19[3]
Honduras[e]	6	6	6	6	6
Hungary[e,4]	55	30[3]	26	26	26
India[e]	2,400	2,450	2,500	2,550	2,600
Indonesia[e]	6	6	6	6	6
Iran[e,6]	11,196[3]	12,000	12,000	12,000	13,000
Ireland[e]	450	450	450	450	450
Israel	107	111	83	10[r]	10
Italy	2,905	2,860	5,459	4,139[r]	4,130
Jamaica	302	364	228	238[r]	230
Japan	5,913	5,796	5,850	5,800[e]	5,750
Jordan	345	334	288	300[e]	300
Kenya[4]	9	9	10	10	10
Laos[e]	774	775[3]	775	775	775

See footnotes at end of table.

TABLE 8—Continued
GYPSUM: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2005	2006	2007	2008	2009[e]
Latvia[e]	220	230 [3]	230	230	230
Lebanon[e]	30	30	30	30	30
Libya[e]	175	200	240	250	250
Luxembourg[e, 4]	(5)	(5)	(5)	(5)	(5)
Macedonia	190	268	256	242 [r]	155
Mauritania	43	45	49	44	45
Mexico[4]	6,252	6,076	6,080 [e]	5,135	5,757 [3]
Moldova	131	186	312	300 [e]	250
Mongolia[e]	25	26	NA [r]	NA [r]	NA
Morocco[e]	600	600	600	600	600
Nicaragua[e, 4]	36 [3]	42 [3]	40	40	40
Niger	17	13	5	9 [r, e]	9
Nigeria[e]	150	169	579	300 [r]	300
Oman[e]	60	60	60	60	80
Pakistan	552	650	620	640 [e]	650
Paraguay[e]	5	5	5	5	5
Peru	150	151	335 [r]	335 [r, e]	355
Poland[4]	1,243	1,353	1,492 [r]	1,500 [r, e]	1,500
Portugal[4]	389	400	400 [e]	300 [e]	300
Romania	502	615	707	800 [r, e]	800
Russia[e]	2,200	2,600 [r]	3,000 [r]	3,600 [r]	2,900 [3]
Saudi Arabia	713	2,101	2,100 [e]	2,300 [e]	2,100
Serbia[e]	45 [7]	45	45	45	45
Slovakia[4]	107	126 [r]	151 [r]	152 [r]	150
South Africa	548	554	627	571	598 [3]
Spain[e, 4]	13,000 [e]	11,500	11,500 [e]	11,500	11,500
Sudan[e, 4]	9	7 [3]	8 [3]	8	8
Switzerland[e]	250	250	250	250	250
Syria	467	444	448	573	403 [3]
Tajikistan	9	9	9 [e]	9 [e]	9
Tanzania[4]	23 [r]	33	53 [r]	53 [r]	53
Thailand	7,113	8,355	8,569	8,500 [r, e]	8,500
Tunisia[e]	113	151	157	165	170
Turkey	3,501	4,370	3,241	3,000 [e]	3,100
Turkmenistan[e]	100	100	100	100	100
Uganda	(5)	(5)	(5) [e]	(5) [e]	(5)
Ukraine	381	376	742	1,158 [r]	1,000 [e]
United Arab Emirates[e]	120	130	150	200	200
United Kingdom[4]	2,000	1,700	1,700 [e]	1,700 [e]	1,700
United States[8]	18,700 [r]	18,600 [r]	15,700 [r]	12,300 [r]	10,400 [3]
Uruguay[e]	5 [r]	5 [r]	5 [r]	5 [r]	5
Venezuela	6	7	7 [e]	7 [e]	7
Yemen	38	44	45	50 [e]	50
Total	147,000 [r]	160,000 [r]	166,000 [r]	155,000 [r]	149,000

[e] Estimated. [p] Preliminary. [r] Revised. NA Not available.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 8, 2010.

[3] Reported figure.

[4] Includes anhydrite.

TABLE 8—Continued

GYPSUM: WORLD PRODUCTION, BY COUNTRY[1,2]

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[5] Less than ½ unit.

[6] Data are for years beginning March 21 of that stated.

[7] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[8] Excludes byproduct gypsum.

HELIUM

By Norbert Pacheco and Deirdre Thomas[1]

In the United States in 2009, sales of Grade-A helium (99.995% or greater purity) by private industry were 46.5 million cubic meters[2] (about 1.68 billion cubic feet) and exports by private producers were 71.1 million cubic meters (about 2.56 billion cubic feet) for total sales of about 118 million cubic meters (about 4.25 billion cubic feet), a 9.2% decrease from that of 2008 (table 1). During 2009, domestic helium sales decreased by 22%, while helium exports increased slightly compared with those of 2008.

Legislation and Government Programs

In 2009, the National Academy of Science initiated a second study, as required by the Helium Privatization Act of 1996 (Public Law 104–273), to reevaluate the impact of selling the helium contained in the Federal helium reserve under the existing pricing mechanism in order to determine if adjustments were needed that would optimize future availability of helium for scientific and industrial uses. This study was completed at the end of 2009 and was released to the public on January 20, 2010 (National Research Council of the National Academies).

Also required by the Act, the Texas Commission on Environmental Quality (TCEQ) issued a conditional certificate of completion for the cleanup of the Exell Helium Plant and was working with the U.S. Environmental Protection Agency to issue a ready-for-reuse determination for the property. Disposal documents were forwarded to the General Services Administration to start the final screening and disposal process.

Production

In 2009, 14 companies operated 20 of 22 privately owned domestic helium plants, 14 of which extracted helium from natural gas; two of the crude helium plants did not produce or extract helium during 2009, and one new small crude plant in Otis, KS, came online in May. All but two extraction plants used cryogenic extraction processes. Total sales of U.S.-produced helium in 2009 decreased by about 9.2% compared with those of 2008. All natural gas processed for helium recovery came from gasfields in Colorado, Kansas, Oklahoma, Texas, Utah, and Wyoming (figure 1). During 2009, 10 private plants purified helium by using pressure swing adsorption technology. Nine privately owned plants that produced Grade-A helium also liquefied helium. The plant operators and plant locations are listed in table 2.

Domestic production data for helium were developed by the U.S. Bureau of Land Management (BLM) from records of the BLM operations as well as from a high-purity helium survey, an annual voluntary canvass of private U.S. operations. Of the eight operations to which a survey request was sent, all responded, and those data plus data from BLM operations represent 100% of the total helium sales and recovery data listed in table 3.

About 9% less helium was withdrawn from the Government's helium reserve at Cliffside field in 2009 than during 2008. Most domestic helium production comes from the midcontinental and Rocky Mountain regions of the United States. The measured helium reserves from which helium is produced are located in approximately 102 gasfields in 11 States. Most of these reserves are contained in the Hugoton field in Oklahoma, Kansas, and Texas; the Panoma field in Kansas; the Keyes field in Oklahoma; the Panhandle West and Cliffside fields in Texas; and the Riley Ridge area in Wyoming.

In conjunction with its program to survey and identify possible new sources of helium, the BLM analyzed 25 natural gas samples from 3 States in 2009.

Consumption

In 2009, private industry supplied 100% of the domestic helium demand. The major domestic end uses of helium were cryogenics (26%), controlled atmospheres (22%), pressurizing and purging (17%), and welding (17%). Other uses included chromatography, lifting gas, and heat transfer (12%); leak detection (4%); and synthetic breathing mixtures (2%) (figure 3). In cryogenics, magnetic resonance imaging applications dominated liquid helium use. The estimated domestic consumption by end use in 2009 was based on revised figures from a 2008 end-use survey conducted by BLM's Helium Operations to determine trends in helium usage.

In 2009, U.S. domestic helium consumption decreased by 22.0% to 46.5 million cubic meters (about 1.68 billion cubic feet) compared with consumption for 2008. This is the fifth consecutive year that U.S. domestic helium sales have decreased. While U.S. consumption decreased during the past 5 years, helium consumption outside the United States has continued to increase. During 2009, U.S. helium exports increased slightly to 71.1 million cubic meters (about 2.56 billion cubic feet) compared with those of 2008 (table 1).

In-kind crude helium sales regulations (43 CFR part 3195) require helium refiners that sell helium to Federal agencies and their contractors to buy an equivalent amount of crude helium from the BLM. In 2009, in-kind crude helium sales were about 4.9 million cubic meters (175.7 million cubic feet). The sales were made to eight companies through contracts with the BLM.

Stocks

The volume of helium stored in the BLM helium conservation storage system, including the conservation pipeline network and the Cliffside field, totaled 519 million cubic meters (about 18.7 billion cubic feet) on December 31, 2009. The storage system contained crude helium purchased under contract by the Government from 1962 to 1973 and privately owned helium extracted by industry from natural-gas-supplying fuel markets and stored under contract. This privately owned helium is returned to the owners as needed for purification to supply private demand. During 2009, 15.8 million cubic meters (568 million cubic feet) of privately owned helium was delivered to the BLM's helium conservation system, and 55.4 million cubic meters (about 2.00 billion cubic feet) was withdrawn, for a net decrease of 39.6 million cubic meters (about 1.43 billion cubic feet) of private helium in storage (table 4, figure 2).

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[1] Resources Evaluation, U.S. Bureau of Land Management, Amarillo Field Office—Helium Operations, Amarillo, TX.

[2] All metric helium volumes herein are at 101.325 kilopascals absolute (14.696 pounds per square inch absolute) and 15 °C (59 °F). Helium volumes, reported in parentheses following metric units, are measured in cubic feet at 14.7 pounds per square inch absolute and 70 °F—1,000 cubic feet (14.7 pounds per square inch absolute and 70 °F) equals 27.737 cubic meters (101.325 kilopascals absolute and 15 °C) and 1 cubic meter (101.325 kilopascals and 15 °C) equals 36.053 cubic feet (14.7 pounds per square inch absolute and 70 °F).

Transportation

Private producers and (or) distributors shipped helium, predominantly as a liquid, in semitrailers, which delivered the liquid helium to distribution centers where some of it was gasified and compressed into trailers and small cylinders for delivery to end users. The remaining liquid helium was sold as bulk liquid or repackaged in dewars of various sizes for delivery.

Prices

In fiscal year 2009, the price that the BLM charged private companies for crude helium was $2.25 per cubic meter ($62.25 per thousand cubic feet), about 3% higher than that of 2008. The BLM crude helium price was set using guidelines included in the Act and is adjusted annually based on the Consumer Price Index for the previous year.

Foreign Trade

In 2009, exports of Grade-A helium increased slightly to 71.1 million cubic meters (2.56 billion cubic feet), and accounted for about 60% of sales of U.S.-produced helium; private industry supplied all U.S. helium exports. The increase in helium exports was attributed to increased shipments of helium to Australia, Belgium, Brazil, Canada, Germany, the Republic of Korea, and Singapore. About 54% of the helium exported from the United States went to Asia, with Japan receiving about 23% of total U.S. exports. About 19% of the exported helium was shipped to Europe; collectively, Belgium, France, Germany, Italy, and the United Kingdom received 97% of the helium exported to Europe. Other exports were as follows: Canada and Mexico, 14%; South America, 8%; Australia and New Zealand, 3%; Africa and the Middle East, 1% each; and Central America and the Caribbean, less than 1% each. For 2009, import tariffs on helium remained at 3.7% for normal trade relations (NTR) nations and 25% for non-NTR nations.

World Review

Excluding the United States, world production capacity of helium was estimated to be about 70 million cubic meters (2.53 billion cubic feet) for 2009 (table 5). In 2009, the helium plants in Algeria and Qatar produced about 10% less helium than in 2008 as a result of a worldwide helium demand decline of about 10% for 2009. During 2009, one small new helium plant came onstream in Australia. Worldwide, eight new helium plant projects were scheduled for startup between 2011 and 2015. Two of the eight projects were scheduled for startup in the Riley Ridge, WY, and St. Johns, AZ, areas between 2011 and 2012. The other new plants will be constructed in Algeria, China, India, Indonesia, Qatar, and Russia. All known helium that was produced outside the United States during 2009 was extracted in Algeria, Australia, Poland, Qatar, and Russia.

Outlook

From 2004 to 2009, the total market for U.S. produced helium declined by about 2% per year, while from 1999 to 2009, the market growth rate was flat. Owing to the slow U.S. economic recovery, U.S. domestic helium consumption was expected to decrease in 2010. Foreign helium demand, however, was expected to increase slightly in 2010. With the anticipation that foreign helium production will remain stable or decline during 2010, increased foreign demand was expected to result in increased U.S. helium exports of about 1% to 2% compared with 2009 exports.

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TABLE 1
TOTAL SALES OF GRADE-A HELIUM PRODUCED IN THE UNITED STATES[1]

(Million cubic meters)

	Volume		
Year	Domestic sales	Exports[2]	Total sales
2005	81.6	51.4	133
2006	75.2	61.9	137
2007	73.5	64.2	138
2008	59.6	69.9	130
2009	46.5	71.1	118

[1] Data are rounded to no more than three significant digits, may not add to totals shown.

[2] Source: U.S. Census Bureau.

TABLE 2
OWNERSHIP AND LOCATION OF HELIUM EXTRACTION PLANTS IN THE UNITED STATES IN 2009

Owner or operator	Location	Product purity
Air Products Helium, Inc.	Hansford County, TX	Grade-A helium.[1]
Do.	Liberal, KS	Do.
BP America, Inc.	Sunray, TX	Crude helium.
Do.	Ulysses, KS	Do.
DCP Midstream, LLC	Cheyenne Wells, CO	Crude and Grade-A helium.[1]
Do.	Hansford County, TX	Crude helium.
Do.	Liberal, KS	Do.
Do.	Borger, TX	Do.
EnCana Oil & Gas (USA) Inc.	Moab, UT	Crude and Grade-A helium.[1]
ExxonMobil Gas & Power Marketing Co.	Shute Creek, WY	Do.
IACX Energy[2]	Otis, KS	Crude helium.
K-L Energy Partners, LLC[3]	Lakin, KS	Do.
Linde Global Helium Inc.	Otis, KS	Grade-A helium.[1]
Midstream Energy Services, LLC	Keyes, OK	Crude and Grade-A helium.[1]
Nacogdoches Oil & Gas, L.L.C.[4]	Shiprock, NM	Grade-A helium.
ONEOK Field Services Co.[3]	Bushton, KS	Crude helium.
Do.[5]	Scott City, KS	Do.
Pioneer Natural Resources Co.	Fain, TX	Do.
Do.	Satanta, KS	Do.
Praxair, Inc.	Bushton, KS	Grade-A helium.[1]
Do.	Ulysses, KS	Do.
SemGas, LP[6]	Dodge City, KS	Crude helium.

Do. Ditto.

[1] Including liquefaction.

[2] Plant came online in May 2009.

[3] Plant did not produce helium during 2009.

[4] Nagocdoches Oil & Gas, L.L.C. purchased plant from Shiprock Helium in 2008.

[5] Output is piped to Ulysses, KS, for purification.

[6] Plant shut down in April 2009.

TABLE 3
HELIUM RECOVERY IN THE UNITED STATES[1]

(Thousand cubic meters)

	2005	2006	2007	2008	2009
Crude helium:					
Bureau of Land Management (BLM) sold (in-kind and open market)	41,400	63,500	58,800	50,300	30,200
Private industry:					
Private helium accepted and stored by BLM	17,000	18,100	15,800	21,600	15,800
Helium withdrawn from storage	-74,100	-75,800	-76,500	-71,500	-55,400
Total net helium put into storage	-57,100	-57,700	-60,700	-49,900	-39,600
Grade-A helium:					
Private industry sold	133,000	137,100	137,700	129,500	117,600
Total helium stored	-57,100	-57,700	-60,700	-49,900	-39,600
Helium recovery from natural gas	75,900	79,400	77,000	79,600	78,000

[1] Negative numbers denote a net withdrawal from BLM's underground storage facility, a partially depleted natural gas reservoir at the Cliffside field near Amarillo, TX.

TABLE 4
SUMMARY OF BUREAU OF LAND MANAGEMENT HELIUM CONSERVATION STORAGE SYSTEM OPERATIONS[1, 2]

(Thousand cubic meters)

	2007	2008	2009
Helium in conservation storage system on January 1:			
Stored under BLM conservation program[3]	634,200	583,500	532,500
Stored for private producers under contract	37,400	27,600	28,000
Total[3]	671,600	611,100	560,500
Input to system:			
Net deliveries from BLM plants	--	--	--
Stored for private producers under contract	15,800	21,600	15,800
Total[3]	15,800	21,600	15,800
Redelivery of helium stored for private producers under contract	-76,500	-71,500	-55,400
Net addition to system[3]	-60,700	-49,900	-39,600
Helium in conservation storage system on December 31:			
Stored under BLM conservation program[3]	583,500	532,500	500,500
Stored for private producers under contract	27,600	28,000	18,600
Total[3]	611,100	560,500	519,100

-- Zero.

[1] Crude helium is injected into or withdrawn from BLM's underground storage facility, a partially depleted natural gas reservoir at the Cliffside field near Amarillo, TX.

[2] Negative numbers denote a net withdrawal from BLM's storage facility.

[3] Net additions to system do not include in-kind crude sales or transfers. Totals, however, do include crude sales and transfers.

TABLE 5
WORLD GRADE-A HELIUM ANNUAL PRODUCTION CAPACITY AS OF DECEMBER 31, 2009

(Million cubic meters)

	Capacity
United States[1]	177
Rest of world[e]	70
Total[e]	247

[e] Estimated.

[1] Includes plants on standby as well as operating plants.

FIGURE 1
MAJOR U.S. HELIUM-BEARING NATURAL GAS FIELDS

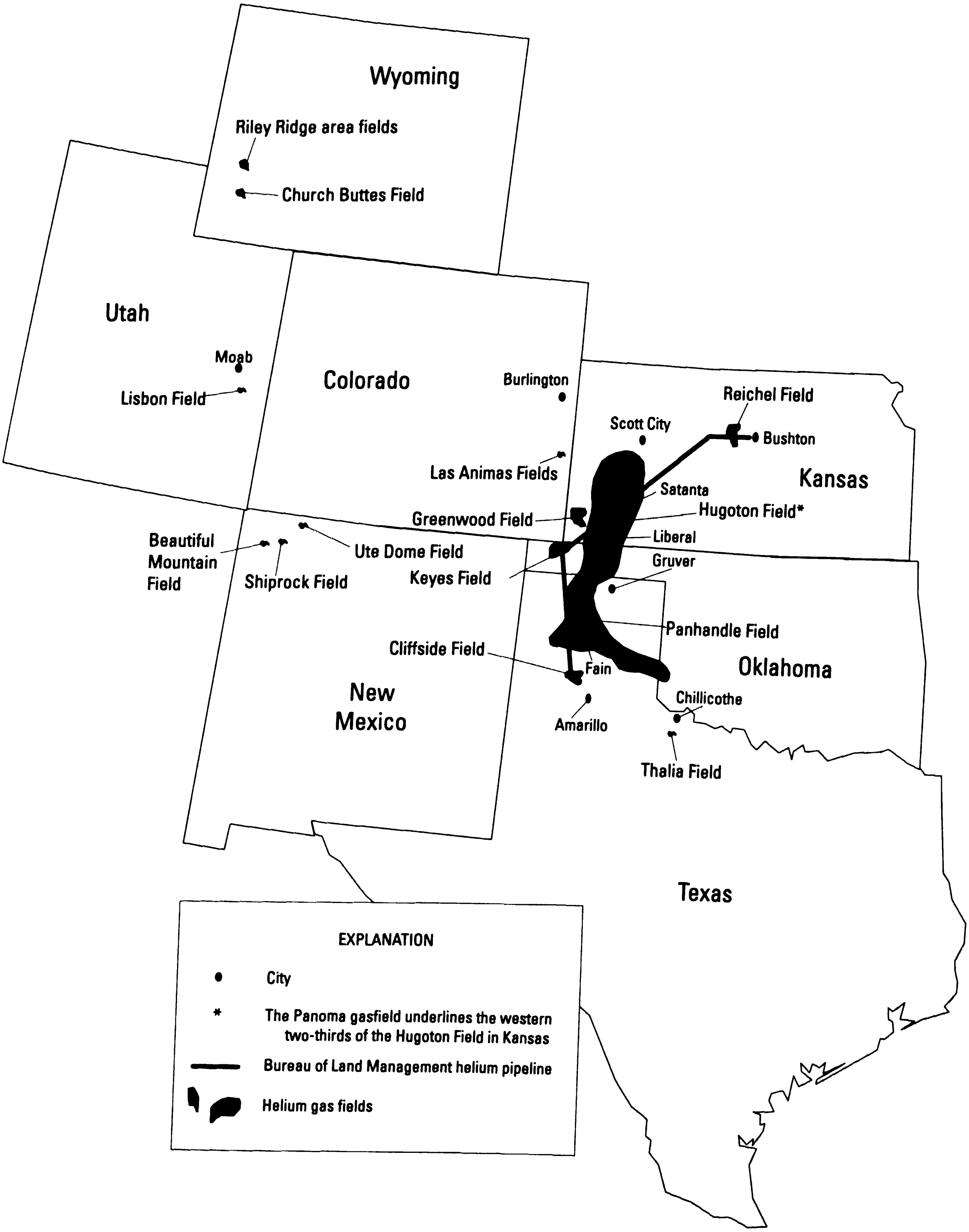


FIGURE 2
HELIUM RECOVERY IN THE UNITED STATES

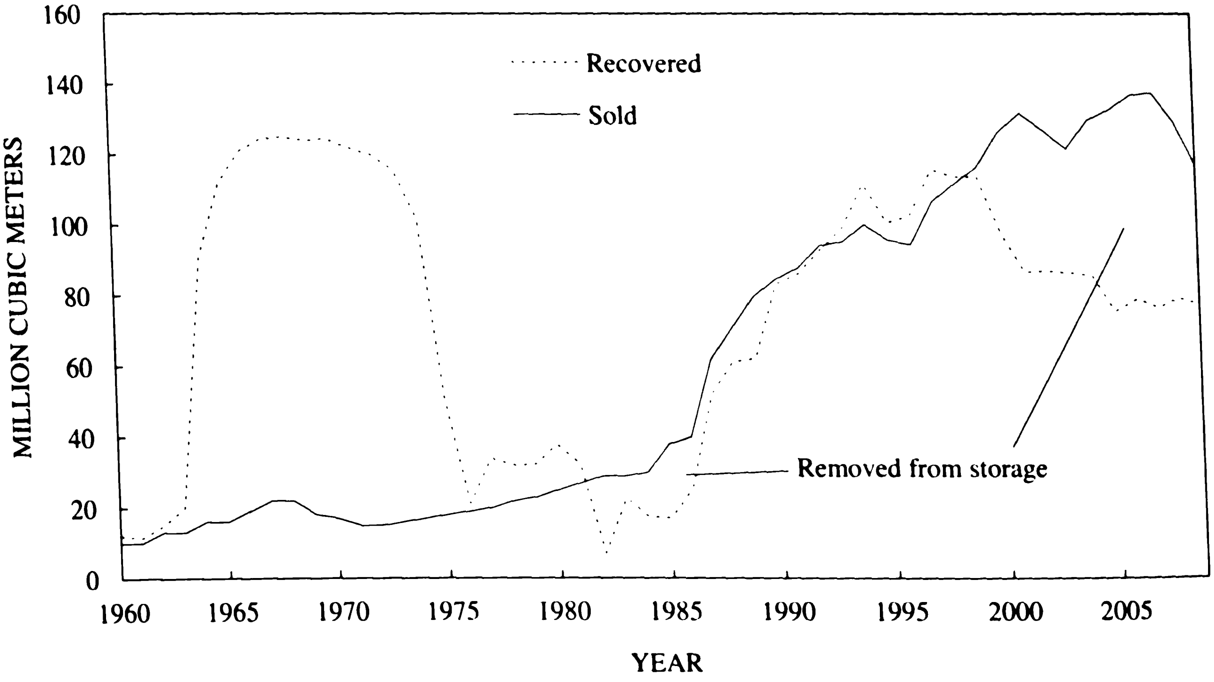
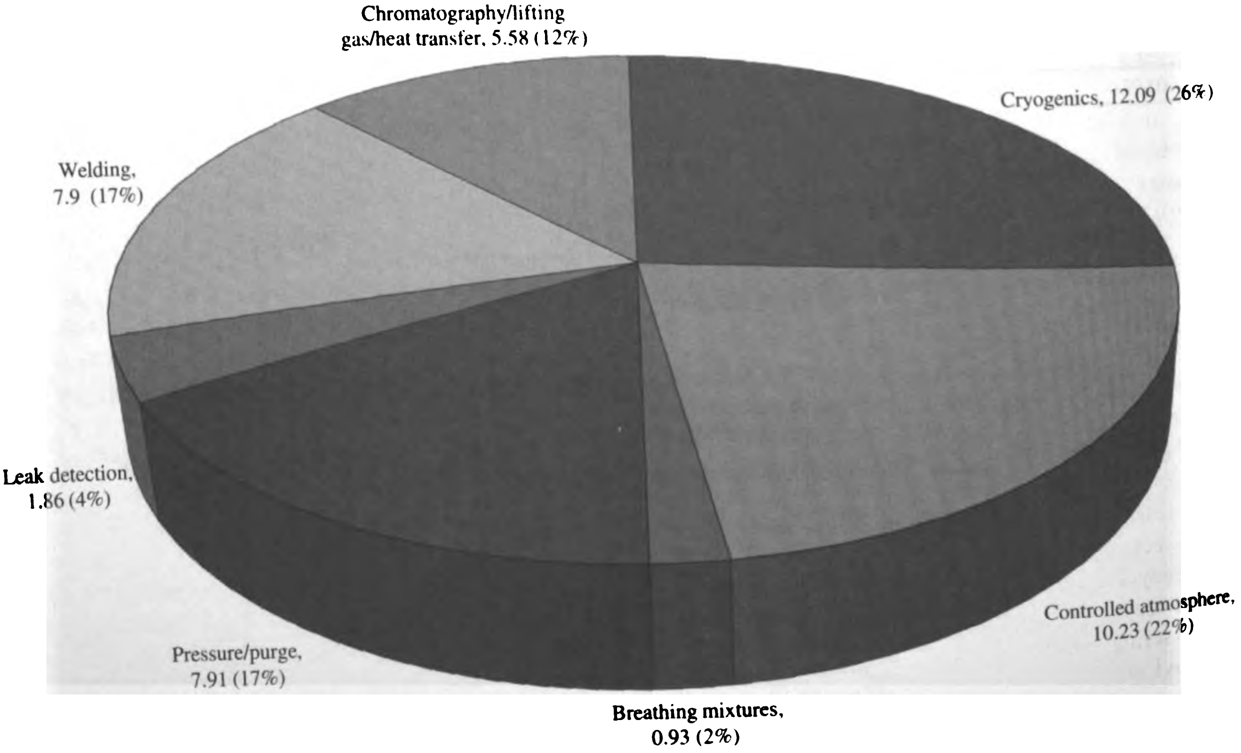


FIGURE 3
ESTIMATED HELIUM CONSUMPTION, BY END USE, IN THE UNITED STATES IN 2009[1]



[1] Total helium used in the United States in 2009 was estimated to be 46.5 million cubic meters.

INDIUM

By Amy C. Tolcin

The domestic table was prepared by Cheryl J. Crawford, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

All refined indium produced in the United States during 2009 came from the refining of lower grade imported indium metal and from refining of scrap. Two refineries, one in New York and the other in Rhode Island, produced the majority of indium metal and indium compounds in 2009. A number of smaller companies produced specialty indium alloys and other indium products.

Production

Though zinc was mined domestically, primary indium was not known to be recovered from these zinc concentrates. Lithic Resources Ltd. (Vancouver, British Columbia, Canada), however, announced a new resource estimate for its Crypto zinc project in Utah, which revealed significant amounts of recoverable indium contained in the deposit. The property was acquired by Lithic in 2005; the company was moving the project toward the prefeasibility stage (Lithic Resources Ltd., 2009).

Indium metal was not produced as a byproduct in the United States at any zinc or lead refineries. Production of indium consisted of upgrading imported indium metal and powder. Lower grade (99.97%) and standard-grade (99.99%) imported indium was refined to purities of up to 99.99999%. Indium Corp. of America, Utica, NY, and Umicore Indium Products, Providence, RI (a division of n.v. Umicore, s.a., Olen, Belgium), accounted for the major share of U.S. production of indium metal and products. Indium metal was sold in various forms (foil, ingot, powder, ribbon, wire, and others) and grades. Many smaller companies produced compounds, high-purity indium alloys, indium tin oxide (ITO) coatings, solders, and other indium products.

Recycling

A large portion of global secondary indium was produced from ITO recycling. Sputtering, the process in which ITO is deposited as a thin-film coating onto a substrate, is highly inefficient; only about 30% of an ITO target is deposited onto the substrate. The remaining 70% resides in the spent ITO target, the grinding sludge, and the after-processing residue left on the walls of the sputtering chamber. It was estimated that 60% to 65% of the indium in a new ITO target will be recovered, and research was underway to improve this rate further. A short recycling process time for used ITO targets is critical, as a recycler may have millions of dollars worth of indium in the recycling loop at any one time, and a large increase in ITO scrap could be problematic owing to increased capital costs, environmental restrictions, and a lack of storage space. It was reported that the ITO recycling process—from collection of scrap to production of secondary materials—now takes less than 30 days. Spent ITO target recycling was concentrated in China, Japan, and the Republic of Korea—the countries where ITO production and sputtering takes place (Phipps and others, 2007; Stevens, 2007, p. 1–16).

Indium may also be reclaimed directly from old liquid crystal display (LCD) panels. The panels are crushed to millimeter-sized particles and then soaked in an acid solution to dissolve the ITO from which the indium is recovered.

Indium recovery from tailings was thought to have been insignificant, as these wastes contain small percentages of the metal and can be difficult to process. However, improvements to the process technology have made indium recovery from tailings feasible when the price of indium is high.

Consumption

Indium Tin Oxide.—Production of ITO was the leading end use of indium, accounting for the majority of global indium consumption. ITO is used for electrically conductive purposes in a variety of flat-panel display devices—most commonly, LCDs. Most ITO production was in Japan. Significant amounts of ITO were also produced in China, the Republic of Korea, and Taiwan.

Global indium consumption was strong during the first quarter of 2009 owing to flat-screen television shipments to North America increasing compared with those of the same period of 2008. In April, Nippon Mining & Metals Corp. (Japan), the leading global producer of ITO, was reported to be operating at 60% to 70% of its rated capacity, up from a 40% to 50% operating rate in December 2008. The increased operating rate was attributed to stronger ITO demand from flat-panel makers in the Republic of Korea, owing to rising flat-panel television shipments to China. During the summer, several ITO producers reportedly returned to full production. By December, most leading Japanese ITO plants were operating at nearly full capacity (Platts Metals Week, 2009e; Roskill's Letters From Japan, 2009; Watanabe, 2009b, c).

Alloys and Solders.—Alloys and solders were the second leading end use of indium. Indium-containing solders have lower crack propagation and improved resistance to thermal fatigue when compared to tin-lead solders. They also inhibit the leaching of gold components in electronic apparatus. Low-melting-point indium alloys are used as fuses or plugs for sprinkler systems. In the optical industry, low-melting-point alloys are applied to lenses and act as a surface for machine tools to grip during the polishing process. Certain types of indium alloys can also be used as a bonding agent between nonmetallic materials, such as glass, glazed ceramics, and quartz. Indium has also been used in dental alloys and in white gold alloys.

Other.—Another important use of indium was for III-V semiconductor materials for light-emitting diodes (LEDs) and laser diodes. In indium-based semiconductors, indium antimonide, indium arsenide, or indium phosphide can be used as the substrate, and several indium-containing compounds can be used as the epitaxial layer (or substrate coating), such as indium gallium arsenide. Indium-based LEDs are used predominantly to optically transmit data and, to a lesser extent, in LED displays. Indium-based laser diodes are used in fiber-optic communications.

Other uses of indium included electrode-less lamps, mercury alloy replacements, and nuclear control rods. Alkaline batteries use indium to prevent buildup of hydrogen gas within sealed battery casings.

Prices

The 2009 average annual Platts Metals Week New York dealer price range for indium [99.99% minimum purity in minimum lots of 50 kilograms (kg)] was $360 to $400 per kilogram. Indium prices began the year ranging from $350 to $400 per kilogram and then declined through May, dipping to $275 to $340 per kilogram. Prices rose until mid-October, reaching $475 to $525 per kilogram. Subsequently, prices declined through the end of November to $400 to $450 per kilogram, after which prices increased during December, ending the year at $460 to $500 per kilogram.

According to Platts Metals Week, the Indium Corp. of America producer price for indium (99.97% purity, 1-kilogram bar in lots of 10,000 troy ounces) began the year at $500 per kilogram and remained unchanged for the entire year.

Foreign Trade

During 2009, U.S. imports for consumption of unwrought indium metal and indium powders totaled 105 metric tons (t), a 27% decrease from the 144 t imported in 2008. Canada surpassed China as the leading supplier in 2009, accounting for 42% of the imports. Other leading suppliers in 2009 were China (18%) and Japan (11%). Belgium, Hong Kong, and the United Kingdom also continued to be significant import sources for indium (table 1). There was no exclusive domestic export classification code for unwrought indium and indium powders.

World Review

Argentina.—Minerals exploration company Argentex Mining Corp. (Vancouver) continued a drilling program to define the mineral resources at its Pinguino property in Santa Cruz. Drilling results at Pinguino revealed the presence of numerous veins containing silver-gold and indium-enriched base-metal mineralization. In September, the company announced its initial resource estimate for Pinguino; resources totaled 7.32 million metric tons (Mt) of ore grading 16.26 grams per metric ton (g/t) indium, and inferred resources totaled 35.4 Mt of ore at 8.89 g/t indium (Argentex Mining Corp., 2009).

Australia.—North Queensland Metals Ltd. (Fortitude Valley, Queensland) continued progress on the Baal Gammon copper, tin, silver, and indium project. North Queensland Metals originally planned to postpone construction of the mine owing to depressed economic conditions. However, the company announced at the end of the third quarter that it had reviewed Baal Gammon's mine design and decided that a smaller high-grade pit may be feasible for mining in the current market. Estimated probable ore reserves at Baal Gammon reportedly were 3.1 Mt of ore grading 29.6 g/t indium (North Queensland Metals Ltd., 2009, p. 18).

Belgium.—Indium metal (foil and ingots) was produced at Umicore's precious metals refinery at Hoboken. A special metals plant at the refinery recovered indium from dusts and residues generated by the facility's lead refinery. Production capacity was 30 metric tons per year (t/yr) of indium.

Bolivia.—Several mines in Bolivia produced indium-bearing concentrates, which were thought to be exported and processed elsewhere.

Canada.—Refined indium was produced at Teck Resources Ltd.'s (Vancouver) lead-zinc metallurgical complex at Trail, British Columbia, and at Xstrata plc's (Zug, Switzerland) Kidd Creek copper-zinc metallurgical operations at Timmins, Ontario. Indium production capacity at Trail was about 75 t/yr. Actual production would be determined by the availability of indium-bearing concentrates. Xstrata produced 11.5 t of refined indium at Kidd Creek in 2009 (Xstrata Copper Canada, 2010, p. 15).

China.—China was a major global producer of primary indium. China Metal Market—Precious & Minor Metals Monthly (2009b) estimated that there were approximately 40 indium producers in China. Huludao Zinc, one of the leading indium refineries in China, had the capacity to produce 50 t/yr of primary indium. In June, the company reached a monthly production record of 3 t of refined indium and 1.34 t of indium sponge.

Around midyear, China's Government launched a series of environmental regulations that restricted nonferrous metals production, including byproduct metals such as bismuth and indium, after emissions from a lead smelter reportedly poisoned several hundred children in Shaanxi Province. In Hunan Province, at least five plants that produced indium were shut down during this time because of pollution problems. The plant closures reduced indium output, which possibly contributed to the higher indium prices during midyear (Ryan's Notes, 2009b).

The 2009 indium export quota was 233 t. The first batch of quotas, released in early 2009, totaled 139.8 t of indium, down 17% from the first export quota total of 2008. The first batch accounted for 60% of total exports for the calendar year and was based on production quantities from 2005 to 2007 and export quantities and values from 2006 to October 2008. The second batch of export quotas, released on June 30, totaled 93.2 t. Leading exporters in 2009 were Hunan Zhuzhou Smelting Plant Torch Metal Import & Export Co., Ltd., Liuzhou China Tin Group Co., Ltd., and Nanjing Foreign Economic & Trade Development Co., Ltd. (China Metal Market—Precious & Minor Metals Monthly, 2009c; Platts Metals Week, 2009a).

China's Government reduced the export tax on indium to 5% from 15%, effective July 1. The Government reduced the tax to increase China's competiveness in the global market. However, it was reported that some producers wanted the tax removed if the tax reduction did not significantly improve market conditions in China. Some licensed exporters claimed that the tax encouraged the smuggling of indium out of the country. Nanjing Germanium Factory Co., Ltd., a secondary indium producer, constructed an indium refining facility in Laos to avoid the export tax (Ryan's Notes, 2009c; Watanabe, 2009a, e).

Annual indium consumption in China in 2009 was reported to be about 40 t, of which 65% was used for the production of ITO and 6% was used for alloys and solders. However, China's indium consumption may significantly increase in the coming years as leading Japanese ITO producers consider constructing ITO plants in China alongside the increased flat-panel display manufacturing that has been taking place in China. Nippon Mining & Metals planned to build an ITO production unit at its facilities in China, which were used to process copper and other metals. The decision was made following announcements made by Japanese, South Korean, and Taiwanese flat-panel makers to increase their production capacities or build new production plants in China. Mitsui Mining & Smelting Co., Ltd. (Japan) was also considering constructing an ITO production base in China. It is uncertain how this will affect global indium consumption, as smaller Japanese ITO producers may not continue to operate if ITO production increasingly shifts to China. However, it was also reported that some Japanese ITO producers were turning down Chinese partnerships in order to protect their proprietary technology (Metal-Pages, 2009b; Watanabe, 2009d).

Suzhou GroupSat Solar Co. began constructing a copper-indium-gallium-diselenide (CIGS) solar cell manufacturing plant in Suzhou, Jiangsu Province, which was scheduled to begin producing in 2010. The plant would have the capacity to produce 25 megawatts per year of CIGS solar cells (China Metal Market—Precious & Minor Metals Monthly, 2009a).

France.—Nyrstar NV's Auby zinc smelter had an indium recovery plant that produced a concentrate grading 20% indium, which was sold to third parties for further processing.

Germany.—Indium was produced at PPM Pure Metals GmbH (Langelsheim) and Norddeutsche Affinerie AG (Hamburg). PPM recovered indium from indium-containing materials at its special metals production facility in Langelsheim. The company produced high-purity indium ingot, semifinished products, and indium compounds. Norddeutsche Affinerie AG also produced high-purity indium, which it consumed for the development of solar cells.

Japan.—In addition to China, Japan was a significant producer of indium. Indium producing-companies included Asahi Pretec Corp., Dowa Metals & Mining Co., Ltd., Nikko Metals, Mitsui Mining & Smelting, Sumitomo Metal Mining Co., Ltd., and Toho Zinc Co., Ltd. Dowa Metals & Mining operated an indium recycling facility in Akita Prefecture. Production capacity at the facility was 150 t/yr of secondary indium. Dowa also had the capacity to produce 70 t/yr of primary indium. Dowa's production was sold to consumers in Japan. Asahi Pretec had the capacity to produce 200 t/yr of secondary indium at its ITO target recycling plant in Fukuoka.

Japan also is a leading consumer of indium. Major Japanese indium consumers included ITO producers Mitsui Mining & Smelting, Nippon Mining & Metals, Sumitomo Metal Mining, Tosoh Corp., and Ulvac Technologies, Inc. Nippon Mining & Metals operated the world's leading ITO production plant—the 50-metric-ton-per-month (t/mo) Isohara plant near Tokyo. In July, the company confirmed plans to further increase ITO production capacity at Isohara by the end of summer owing to increased flat-panel demand in China and the United States. However, the size of the increase was not announced. Mitsui Mining & Smelting reportedly operated the second leading ITO manufacturing plant, the Omuta plant in southern Japan, which had the capacity to produce about 20 to 30 t/mo of ITO. Dowa estimated that Japanese indium consumption in 2009 totaled 602 t, with 525 t (87%) used for the production of ITO. Primary indium consumption was 240 t, with 70 t (29%) from domestic producers, and the balance was imported. Secondary indium consumption was 362 t (Platts Metals Week, 2009d, e; Roskill's Letters From Japan, 2009).

The Japanese Government planned to include gallium and indium in its rare-metal stockpile. Japan's metal stockpile was created to support stable economic conditions for key domestic industries that consumed these metals. The Ministry of Economy, Trade, and Industry requested a $2 million supplementary budget for stockpiling; a portion of this budget would be allotted for purchasing gallium and indium. Once the budget was approved, Japan Oil, Gas, and Metals Corporation (the government agency that manages the stockpile) would purchase the metal from domestic producers or consumers. The amount of indium held in the stockpile would be equivalent to 42 days worth of domestic consumption (Platts Metals Week, 2009b).

Korea, Republic of.—The Republic of Korea also held a stockpile of indium. In addition to indium, the country stockpiled other metals—such as aluminum, cobalt, copper, manganese, molybdenum, nickel, silicon, and vanadium—to prepare for national emergencies. In 2009, the Government budgeted $200 billion for the national metal stockpile, of which 20% was allocated for the procurement of minor metals, including indium. In 2008, the Republic of Korea's Public Procurement Service was reported to have purchased 5 t of indium from Korea Zinc Co., Ltd. for the stockpile (Platts Metals Week, 2009b, c).

Korea Zinc produced primary and secondary indium at its Onsan zinc refinery. Production capacity at the plant was thought to be 200 t/yr of indium, of which 100 t/yr was primary and 100 t/yr was secondary. Secondary feedstock was sourced from Japanese ITO producers.

Peru.—Refined indium was produced at Doe Run Peru's La Oroya metallurgical complex (temporarily closed as of June 2009) and Votorantim Metais' Cajamarquilla zinc refinery. Votorantim began producing indium at Cajamarquilla in late December 2008. Initial production capacity was forecast to be 38 t/yr of indium. However, capacity may increase to 76 t/yr of indium after an ongoing expansion project at the refinery is complete (Votorantim Metais, 2008).

Russia.—Chelyabinsk Zinc Plant OJSC and Ural Mining and Metals Co. (UMMC) produced refined indium. In 2009, annual production in the country was between 4 and 5 t, most of which was thought to be exported. About 1 t of total production was recovered from secondary materials (Metal-Pages, 2009a).

Outlook

Long-term demand for indium was expected to continue to rise as the flat-panel market continues to expand, assuming that flat-panel display manufacturers continue to rely on ITO as the transparent conducting material. Although ITO substitutes have been developed, there is no evidence of a significant shift towards the use of these alternative materials in flat-panel displays. The LCD market still has significant room for growth; LCD television penetration has remained low, according to Corning Inc. The company estimated that only 8% of installed televisions worldwide were LCDs. Toshiba expected global sales of its LCD televisions during fiscal year 2011 to increase by 80% compared with sales in fiscal year 2009 owing to increased demand in emerging markets. The Japan Electronics and Information Technology Industries Association forecasted global demand for flat-screen televisions would increase to 180 million units in 2012 from 86.2 million units in 2007 (Ryan's Notes, 2008, 2009a).

The solar cell industry is experiencing growth, and the amount of indium consumed for this market may increase substantially in the future. According to Indium Corp., indium demand for thin-film CIGS solar cells potentially could increase to 300 t/yr by 2013. Indium consumption for CIGS in 2009 was nearly 30 to 35 t/yr. Strong investment in CIGS solar cell projects coupled with new or recently expanded manufacturing plants in Europe, Japan, and the United States indicated that indium consumption for solar cells was expected to increase globally (Platts Metals Week, 2008; Watanabe, 2008).

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TABLE 1
U.S. IMPORTS FOR CONSUMPTION OF UNWROUGHT INDIUM METAL, BY COUNTRY[1]

Country	2008 Quantity (kilograms)	2008 Value (thousands)	2009 Quantity (kilograms)	2009 Value (thousands)
Belgium	12,100	$5,360	8,790	$2,860
Canada	27,900	13,400	44,600	13,400
China	51,200	27,000	19,000	7,040
Costa Rica	87	9	--	--
Germany	848	381	57	19
Hong Kong	5,490	1,860	5,910	2,050
Israel	28	5	--	--
Japan	25,800	12,000	12,000	3,690
Korea, Republic of	2,020	1,030	3,320	973
Malaysia	23	3	322	69
Peru	2,660	1,110	2,570	737
Singapore	237	119	--	--
Sweden	169	25	--	--
Switzerland	213	26	594	26
Taiwan	876	152	1,600	563
United Kingdom	14,200	7,070	6,500	3,780
Total	144,000	69,500	105,000	35,200

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 2
INDIUM: ESTIMATED WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2005	2006	2007	2008	2009
Belgium	30	30	30	30	30
Brazil	--	--	--	--	5
Canada	45	50	50	45	40
China	370 r	400 r	370 r	340 r	280
Germany[3]	10	10	10	10	10
Italy	5	5	5	5	5
Japan	70	55	60	65	67
Kazakhstan	(4) r	(4) r	(4) r	(4) r	(4)
Korea, Republic of	50	60 r	70	75	70
Netherlands	5	5	5	5	5
Peru	7 r	6	5 r	6	25
Russia	10 r	10 r	10 r	10 r	4
Ukraine[5]	NA	NA	NA	NA	NA
United Kingdom	5	5	5	5	5
Total	607 r	636 r	620 r	601 r	546

r Revised. NA Not available. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 4, 2010.

[3] Production of indium reinstated, because both PPM Pure Metals GmbH (PPM) and Norddeutsche Affinerie AG (NA) reported that they were producing indium in 2007. NA is reportedly using its own indium in designing new solar cell technologies, but no estimates of indium production were actually available. This data represents only estimated production by PPM at the company's Langelsheim special metals plant.

[4] Less than ½ unit.

[5] Information is not adequate to estimate production.

IODINE

By Marc A. Angulo

Domestic survey data and tables were prepared by Cheryl J. Crawford, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

Iodine production and apparent consumption in the United States decreased in 2009 compared with that of 2008. Data for production and apparent consumption were withheld to avoid disclosing company proprietary data. Reported consumption by producers and consuming industries was 4,550 metric tons (t) in 2009 compared with 4,590 t in 2008. Crude and sublimed iodine exports increased to 1,160 t valued at $22.9 million in 2009 compared with 950 t valued at $17.4 million in 2008. Imports of crude iodine decreased to 5,190 t valued at $133 million in 2009 compared with 6,300 t valued at $144 million in 2008. World production, excluding United States production, was estimated to be 28,500 t in 2009 compared with 26,500 t in 2008.

Legislation and Government Programs

After a 1-year trial period and extensive study of health effects, the U.S. Environmental Protection Agency (EPA) approved the restricted use of the soil fumigant iodomethane (methyl iodide) as an alternative to the ozone depleting methyl bromide. In May, the EPA concluded its reevaluation of the fumigant and mandated regulations on all users. Under the regulations effective September 2008, companies must provide training for employees and satisfy risk mitigation requirements set by the EPA. Respirators or ducted fan and blower systems must be used by workers applying the fumigant. Tarps must be placed over treated fields, and buffer zones must be established around fields where the fumigant will be applied. Use of the fumigant is prohibited within a specified distance from such sites as day care facilities, nursing homes, prisons, and schools. Methyl iodide can be used to control insects, nematodes, plant pathogens, and weeds and may be used on crops and plants such as ornamentals, peppers, strawberries, tomatoes, trees, turf, and vines. Field tests were underway in Washington to determine if the climate—weak sunlight intensity and cooler temperatures—reduced the dissipation of the fumigant, leading to a risk of overexposure (Chemical and Engineering News, 2008; U.S. Environmental Protection Agency, 2009).

Production

The U.S. Geological Survey derived domestic production data for iodine from a voluntary canvass of two U.S. operations (table 1). U.S. production decreased slightly in 2009 from that of 2008. Data were withheld to avoid disclosing company proprietary data.

IOCHEM Corp. (a subsidiary of Toyota Tsusho America, Inc.) produced iodine near Vici, Dewey County, OK. Woodward Iodine Corp. (owned by Ise Chemical Corporation of Japan) produced iodine near Woodward, Woodward County, OK.

Iofina plc (United Kingdom) completed development of its Atlantis prospect in northern Montana, which included drilling its first production well, construction of iodine and gas separation buildings, and laying a 9-mile long gas pipeline extension. Iofina commenced continuous iodine production in late July. The prospect consists of sodium chloride brine with high concentrations of iodine, located between two major biogenic gas fields. The company was also considering development of its Triton prospect, a 30,000-acre site located in southern Montana (Iofina plc, 2008a; 2009a, p. 1). By implementing its Wellhead Extraction Technology (WET), a method that is expected to reduce operating costs and capital expenditures, Iofina contended that both locations would prove to be economically successful (Iofina plc, 2008b; 2009a, p. 3). In August 2009, Iofina acquired Kentucky-based H&S Chemical with the intent to produce and sell iodine derivatives based on its iodine production (ICIS Chemical Business, 2009).

Consumption

U.S. apparent consumption of iodine, which is withheld to avoid disclosing company proprietary data, decreased by 20% in 2009 from that of 2008. Reported consumption by consuming industries was 4,550 t in 2009 compared with 4,590 t in 2008. Accurate end-use statistics are difficult to gather since domestic and imported iodine were used to produce many intermediate iodine compounds, usually by downstream manufacturers. However, 18 of the 22 companies to which a survey form was sent responded to the annual or preliminary surveys, representing 81% of the total consumption by major domestic users of iodine (tables 1, 2).

Uses for iodine in manufacturing decreased by 1% in 2009 compared with those of 2008 (table 2). Production of crude iodine and iodophors decreased by 27% and 31%, respectively, and potassium iodide (KI) production decreased by about 59%. Increased use of crude iodine was reported by several companies. Two companies accounted for the bulk of the decrease in use of iodine for iodophors. One company accounted for the decrease in use of iodine for KI. Other inorganic and organic iodine compounds increased in tonnage.

Specifications

Commercial crude iodine normally has a minimum purity of 99.5% to 99.8%, depending on the supplier. Impurities, in order of quantity, are primarily insoluble materials, iron, sulfuric acid, and water. The U.S. Pharmacopeia specifies an iodine content of not less than 99.8% for commercial iodine. The Committee on Analytical Reagents of the American Chemical Society allows a maximum of 0.005% total bromine and chlorine and 0.010% nonvolatile matter in its specifications for iodine.

Biocides and Disinfectants.—Since iodine is one of the most effective medical antiseptics available, it was used in biocides and disinfecting chemicals. Iodophors, chemical complexes designed to carry large amounts of iodine which are highly water soluble, were incorporated into disinfectants for use in dairies, food processing plants, hospitals, and laboratories. The iodophor, polyvinyl pyrrolidinone-iodine (PVP), was used owing to its bactericidal, fungicidal, germicidal, and general disinfecting properties. The National Aeronautics and Space Administration (NASA) uses iodine in its water disinfection process on all manned space flights and in the international space station. Iodine is a cost-efficient, effective, and simple means of water disinfection.

Catalyst.—Iodine catalysts were used to manufacture acetic acid and synthetic rubbers. Acetic acid was used in the manufacture of certain adhesives, dyes, pharmaceuticals, plastics, surface coating, and vinegar. Iodine is employed in the production of acetic acid using the Monsanto process. Catalysts were generally recycled and reused in new processes.

Chemicals.—Iodine is used as a stabilizer in the manufacture of nylon for tire cord and carpets and for converting resins, tall oil, and other wood products to a more stable form.

Nutrition.—Iodine was an essential component of thyroid hormones, which directly affect processes in the brain, muscles, heart, pituitary gland, and kidneys. Iodine deficiency causes goiter in adults, increased mortality and impaired cognitive development in children, and reproductive failure. Iodine deficiency disorder can be prevented by consuming about 150 milligrams of iodine per day for a human adult (Institute of Medicine of the National Sciences, 2006).

Owing to expanded salt iodization campaigns to reduce iodine deficiency, 70% of households in the developing world consumed iodized salt in 2009, compared with only 20% in 1990 (Micronutrient Initiative, 2009). Iodized salt is table salt mixed with a minute amount of iodate, KI, or sodium iodide. Bakers in Australia and Belgium are mandated by law to only use iodized salt in their bread to fight iodine deficiency in their countries (Drake, 2009; Expatica, 2009).

Pharmaceuticals.—Radiopaque agents, drugs that absorbs x rays, are used to help diagnose certain medical ailments and may contain iodine. Radiopaque-diagnosed medical problems include brain disorders, cardiac disease, central nervous system disorders, cerebrospinal fluid, disk disease, gastrointestinal (gall bladder) disorders, peritoneal disorders, splenic and portal vein disorders, urinary track disorders, and vascular disease. Potassium iodide was used as an expectorant in cough medicines. Hydriodic acid and KI were used in the synthesis of amphetamine, ethylamphetamine, and methamphetamine, which are regulated stimulants. The isotope I–131 was used to treat thyroid cancer and hyperthyroidism.

Other Uses.—Developments in digital imaging have produced electronic prints and overhead transparencies without the need for wet processing film. The majority of current feature films, however, were reliant on printed film for shooting since film provides higher image resolution. In the next decade, uses of iodine in films and processing may be limited to specialty film imaging as digital imagery technology for motion pictures improves and digital equipment and printers become more affordable.

Using iodine as a radiocontrast agent in x-ray imaging has been found to increase the risk of kidney failure and should be used with caution on patients with impaired kidney function (Tung, 2006). Barium sulphate, which was used primarily in digestive system imaging, can be used as an iodine substitute but is also known to cause complications. Many elements have higher atomic numbers than iodine; however, no other element has the chemical characteristics that allow iodine to form soluble compounds with low toxicity. It is these latter properties which make iodine-containing contrast media suitable for radiography.

Iodine is used for manufacturing iodine-adsorbed polyvinyl alcohol polarizing films for liquid crystal displays (LCD) for electronic equipment, including appliances, computers, digital cameras, personal handheld devices, and televisions. Polarizers are added to LCDs to enhance the light contrast between the screen and the liquid crystals, making the LCD more visible. These polarizers are usually made from stretched polyvinyl alcohol films that contain iodine.

Prices

Prices for iodine and its derivatives continued to increase in 2009. The average free alongside ship (f.a.s.) value for exported crude iodine in 2009 was $19.74 per kilogram, an increase from $18.30 per kilogram in 2008. The average declared cost, insurance, and freight (c.i.f.) value for imported crude iodine was $25.54 per kilogram in 2009, an increase from $22.90 per kilogram in 2008. The average declared c.i.f. value for iodine imported from Chile, the major source of imported iodine for the United States, was $26.59 per kilogram in 2009 compared with $23.57 per kilogram in 2008. The average declared c.i.f. value for imported crude iodine from Japan was $19.90 per kilogram in 2009, an increase from $19.40 per kilogram in 2008.

The price of crude crystal iodine, 99.5% minimum purity, in 50-kilogram drums delivered to the United Kingdom ranged from $28.50 to $30 per kilogram in January. In December, the price increased to $30.80 to $31.80 per kilogram (Industrial Minerals, 2009d, e).

Actual prices for iodine are negotiated on long- and short-term contracts between buyers and sellers.

Foreign Trade

Net trade is not easily defined since iodine was exported and imported in many forms other than elemental iodine and KI. Exports of crude iodine increased to 1,160 t with an f.a.s. value of $22.9 million in 2009 compared with 950 t valued at $17.4 million in 2008 (table 3). Exports of KI decreased to 126 t with an f.a.s. value of $2.7 million in 2009 compared with 568 t valued at $11.3 million in 2008. Imports of crude iodine decreased to 5,190 t with a c.i.f. value of $133 million in 2009 compared with 6,300 t valued at $144 million in 2008 (table 4). Imports of KI decreased to 259 t with a c.i.f. value of $6.0 million in 2009 compared with a total of 564 t valued at $12.1 million in 2008.

World Review

World production of iodine, excluding the United States, was estimated to be 28,500 t in 2009 compared with 26,500 t in 2008 (table 5). Chile was the world's leading producer of iodine, followed by Japan and the United States.

World consumption of iodine and its derivatives was estimated to be 25,500 t in 2009, a 13% decrease from 29,200 t in 2008. Production from Chile accounted for 53% of that tonnage; Japan accounted for 25%; and the United States accounted for 5%. Other producing countries accounted for 3% of the iodine supply, and iodine recycled in the manufacturing process accounted for 14% (Sociedad Química y Minera de Chile S.A., 2010a, p. 12). Human and animal health and nutrition represented 55% of iodine consumption in 2009, with x-ray contrast media, disinfectants, and LCD screen manufacture representing the other major end uses (Sociedad Química y Minera de Chile S.A., 2009, p. 16; 2010a, p. 12). Under the category for other or unknown applications, an estimated 16% of iodine consumption may be in industrial catalysts (Kanto Natural Gas Development Co., Ltd., undated).

The leading consuming region was Western Europe, with 39% of world consumption, followed by the North America with 24% of world consumption, China with 8%, Japan with 7%, and India with 6%. A breakout was not available for the remaining 16% of world consumption (Iofina plc, 2009b).

European Union.—The European Union announced that the 27 member countries are prohibited from using or selling iodine for the purpose of disinfecting drinking water after October 10, 2009 (Paddling Instructor, 2009). Iodinating water is considered a safe means of disinfection if consumed during short periods. However, according to the U.S. Center for Disease Control, chronic exposure to iodinated water may result in adverse health effects, and ingestion is not recommended by persons with thyroid disease or known iodine allergy or by pregnant women.

Chile.—Sociedad Química y Minera de Chile S.A. (SQM), the largest iodine producer in Chile, reported sales of 7,200 t of iodine and iodine derivatives valued at $190 million in 2009 compared with 10,500 t valued at $247 million in 2008. The decrease in sales was attributed to the global economic downturn, which adversely affected sales of biocides used in the automotive industries and construction (Sociedad Química y Minera de Chile S.A., 2010b). In response to the downturn, SQM announced the suspension of operations at its El Toco and Pampa Blanca mining facilities. In the event of a faster than expected recovery in the iodine market in the coming years, the company thinks its available inventory and installed capacity would allow it to respond rapidly (Sociedad Química y Minera de Chile S.A., 2010c). SQM estimated that it held 25% of the world market for iodine and its derivatives (Sociedad Química y Minera de Chile S.A., 2010a).

ACF Minera, the third leading iodine producer in Chile, started a new project at Algorta, Region II which was expected to replace its current operation at Lagunas, Region I (Industrial Minerals, 2009c).

Atacama Minerals Corp., a publicly held Canadian company operating the Aguas Blancas mine in northern Chile, commissioned an agitated leaching processing plant in late 2008 with the intent to increase production to 1,500 metric tons per year (t/yr) of iodine from 1,000 t/yr. The $26.5 million plant was expected to increase recovery of iodine to more than 75% from 55%, reduce processing time from several months to less than 24 hours (reducing the need for new heap-leach pad construction), and reduce water consumption by 25%. However, full startup had been delayed since the crushing and grinding section of the plant was inadequate to handle the higher than expected sodium sulfate levels found in the mine. In late 2009, the company announced plans to reconfigure the crushing and grinding circuit to adequately handle the various ore types and have the plant fully operational in 2011. To mitigate any loss of production during this transition, the company increased the amount of ore delivered to its heap-leach operations (Atacama Minerals Corp., 2008, 2009).

Turkmenistan.—Two new iodine operations were expected to become operational in Balkan Welayaty. A plant in Hazar, formerly Cheleken, was expected to produce 350 t/yr of iodine and a plant in Khazar Boyadag was expected to produce 300 t/yr of iodine (News Central Asia, 2009).

Outlook

The Chilean producers, which produced 53% of the global iodine supply in 2009, were operating near capacity and were expected to expand production in response to changes in demand. Prices continued to increase owing to an imbalance between supply and demand observed in 2008 and 2009 (Industrial Minerals, 2009b).

The economic slowdown experienced in most countries directly affected nylon production for the automotive industry, biocides in paints for construction, and polarizing films for LCDs. Demand in the health and human nutrition sectors remained steady during the economic downturn and were expected to remain steady throughout 2010. New applications in agrochemicals were expected to increase demand for iodine. SQM projected overall demand in these markets to normalize by the end of 2010 (Industrial Minerals, 2009a; Sociedad Química y Minera de Chile S.A., 2010a).

Demand in other segments of the iodine market was likely to be maintained. The water treatment market was expected to increase, with more growth anticipated in Asian areas. Expanding treatment of municipal water supplies could increase the demand for biocides and disinfectants in the future.

As more countries implement legislation mandating salt iodization, the global demand for iodized salt is expected to increase.

Use of x-ray contrast media, which contain as much as 60% iodine, was expected to increase. More medical tests on an aging population could possibly result in increased demand for iodine-containing x-ray contrast media.

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TABLE 1
SALIENT IODINE STATISTICS[1]

(Metric tons and dollars)

	2005	2006	2007	2008	2009
United States:					
Production	1,570	W	W	W	W
Imports:					
Quantity, for consumption[2]	6,250	5,640	6,060	6,300	5,190
Price, average[3] dollars per kilogram	16.75	19.34	21.01	21.52	25.55
Exports[2]	2,430	1,580	1,060	950	1,160
Consumption:					
Reported[4]	4,680	4,570	4,470	4,590	4,550
Apparent[5]	5,600	W	W	W	W
World, production[e]	26,500	26,700	26,300	26,500	28,500

[e] Estimated. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Source: U.S. Census Bureau information reported by Harmonized Tariff Schedule of the United States code 2801.20.0000.

[3] Cost, insurance, and freight valuation.

[4] Reported by voluntary response to the U.S. Geological Survey from a survey of domestic establishments.

[5] Calculated using domestic production plus imports minus exports plus adjustments for government and domestic industry stock changes.

TABLE 2
DOMESTIC CONSUMPTION OF IODINE, BY PRODUCT[1]

Product	2008 Number of plants	2008 Quantity (metric tons)	2009 Number of plants	2009 Quantity (metric tons)
Inorganic compounds:				
Crude iodine	7 [r]	688	7	505
Resublimed iodine	7 [r]	45	7	62
Potassium iodide	4 [r]	410	4	167
Sodium iodide	5	112	5	193
Hydriodic acid	3	78	3	195
Potassium iodate	3	28	3	17
Miscellaneous iodate, and iodides[2]	2	38	2	37
Other inorganic compounds	5	439	5	510
Total	XX [3]	1,840	XX [3]	1,690
Organic compounds:				
Ethylenediamine dihydroiodide	2	211	2	231
Povidine-iodine (iodophors)	2	468	2	321
Other organic compounds[4]	9	2,070	7	2,310
Total	XX [3]	2,750	XX [3]	2,860
Grand total[5]	XX	4,590	XX	4,550

[r] Revised. XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes ammonium iodide, calcium iodate, and cuprous iodide.

[3] Nonadditive because some plants produce more than one product concurrently.

[4] Includes methyl and (or) ethyl iodide and other unspecified products.

[5] Reported by voluntary response to the U.S. Geological Survey in a survey of domestic establishments.

TABLE 3

U.S. EXPORTS OF CRUDE IODINE AND POTASSIUM IODIDE, BY COUNTRY OF ORIGIN[1]

Type and country of origin[3]	2008 Quantity (metric tons)	2008 Value[2] (thousands)	2009 Quantity (metric tons)	2009 Value[2] (thousands)
Iodine, crude/resublimed:				
Argentina	2	$22	8	$76
Belgium	6	143	1	23
Canada	137	2,990	154	3,570
Costa Rica	(4)	4	8	8
Egypt	--	--	5	144
El Salvador	--	--	6	42
France	12	92	1	29
Germany	667	11,800	779	15,300
Italy	35	788	90	2,180
Japan	11	168	14	222
Malaysia	11	53	2	13
Mexico	52	964	67	854
Other[5]	22	241	25	425
Total	950	17,400	1,160	22,900
Potassium iodide:[6]				
Australia	30	578	6	164
Brazil	(4)	4	3	37
Chile	98	1,940	--	--
France	327	6,840	29	792
Guatemala			5	100
Korea, Republic of	11	133	12	108
Kuwait	23	140	(4)	8
Malaysia	6	184	1	32
Mexico	14	301	10	297
Netherlands	6	183	1	15
Taiwan	47	607	40	610
Turkey	6	155	8	245
Other[7]	1	71	11	310
Total	568	11,300	126	2,720

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Declared free alongside ship valuation.

[3] Export information for crude and resublimed iodine and potassium iodide are reported by Harmonized Tariff Schedule of the United States codes 2801.20.0000 and 2827.60.2000, respectively.

[4] Less than ½ unit.

[5] Includes countries with quantities less than 10 metric tons.

[6] Potassium iodide contains 76% crude iodine.

[7] Includes countries with quantities less than 3 metric tons.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS OF CRUDE IODINE AND POTASSIUM IODIDE FOR CONSUMPTION, BY COUNTRY OF ORIGIN[1]

	2008		2009	
Type and country of origin[3]	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Iodine, crude:				
Chile	5,290	$125,000	4,290	$114,000
France	46	833	7	187
India	--	--	19	615
Japan	963	18,700	871	17,300
Other[4]	(5)	21	2	25
Total	6,300	144,000	5,190	133,000
Potassium iodide:[4, 6]				
Brazil	165	2,610	22	632
Canada	258	5,730	183	4,560
Chile	112	3,500	35	471
United Kingdom	23	163	8	188
Other[4]	7	141	11	144
Total	564	12,100	259	6,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Declared cost, insurance, and freight valuation.

[3] Import information for crude iodine and potassium iodide are reported by Harmonized Tariff Schedule of the United States codes 2801.20.0000 and 2827.60.2000, respectively.

[4] Includes countries with quantities less than 10 metric tons.

[5] Less than ½ unit.

[6] Gross potassium iodide contains 76% crude iodine.

Source: U.S. Census Bureau.

TABLE 5
CRUDE IODINE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2005	2006	2007	2008	2009
Azerbaijan	300	300	300	300	300
Chile[3]	15,346 [4]	16,494 [4]	15,473 [4]	15,503 [4]	17,399 [4]
China	550	560	570	570	580
Indonesia	75	75	75	75	75
Japan	8,095 [4]	8,724 [4]	9,282 [4]	9,500	9,600
Russia	300	300	300	300	300
Turkmenistan	270	270	270	270	270
United States	1,574 [4]	W	W	W	W
Uzbekistan	2	2	2	2	2
Total	26,500	26,700	26,300	26,500	28,500

W Withheld to avoid disclosing company proprietary data; not included in total.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 24, 2010.

[3] Includes iodine production reported by Servicio Nacional de Geologia y Minería.

IRON AND STEEL

By Michael D. Fenton

Domestic survey data and tables were prepared by Hoa P. Phamdang, statistical assistant, and world production tables were prepared by Glenn J. Wallace, international data coordinator.

The global economic recession, which caused the global and U.S. steel industries to contract during 2008, continued into 2009. The longest recession (18 months) ever to occur in the United States was declared over in June 2009 by the National Bureau of Economic Research (Aversa, 2010), but consumer demand remained weak through yearend. The contraction of the U.S. steel industry continued into 2009 with lower operating levels and additional layoffs. Capacity utilization for raw steel production dipped to a low of 41% in April and rose to 62% by the end of the third quarter of 2009. Idling blast furnaces, declining steel prices, decreasing steel-product demand, and decreasing steel service center inventories caused employee layoffs at several steel plants and downstream industries.

The U.S. steel industry suffered from the weakened demand for steel materials by the automotive industry, related to the economic recession. Greater long-term concern was based on the threat of higher Government fuel standards, which would promote substitution of aluminum, carbon fiber, magnesium, plastics, and titanium for steel. Under new proposed standards, U.S. passenger vehicles and light trucks would be required to raise fuel efficiency by 5% yearly to an average of 35.5 miles per gallon by 2016 (Crangle, 2009).

According to the World Steel Association (WSA) (2010a), China was the top steel producer in the world during 2009 [568 million metric tons (Mt)], with its leading steelmaker, Baosteel (31.3 Mt), placing second behind the world's leading steelmaker ArcelorMittal (77.5 Mt). India became the world's third-leading steel producer (56.6 Mt), followed by the United States (59.4 Mt), and Russia (59.2 Mt). China ranked first in the world for total exports and net exports of steel, followed by Japan. The United States ranked first in the world for net imports of steel and fourth for total imports of steel.

The American Iron and Steel Institute (AISI) reported U.S. production of iron and steel and shipments of steel mill products. These data can be regarded as representing 100% of the raw steel producers in the United States. World production of iron and steel was reported by the WSA and by foreign government agencies. Consistent with international usage and Federal Government policy, the U.S. Geological Survey reported all data on iron and steel in metric units unless otherwise noted.

Environment

Climate change continued to be a significant world political issue. According to the AISI (2009a), this global problem can only be addressed effectively by lowering carbon dioxide (CO_2) emissions globally. In mid-2009, the WSA announced its Climate Action recognition program, which recognized steel producers who fulfilled their commitment to participate in the organization's voluntary CO_2 emissions data collection program. Two-thirds of the membership took part in the first round of data collection, which was a globally consistent calculation methodology that would allow production-normalized emission comparisons between plants and regions (World Steel Association, 2007, 2009).

The U.S. steel industry has reduced its energy consumption per ton of steel shipped by almost one-third since 1990 (American Iron and Steel Institute, 2009c). During the same period, CO_2 emissions were reduced by 17%. The U.S. steel industry has the lowest average CO_2 emissions per ton of steel produced in the global steel industry (American Iron and Steel Institute, 2009a). In 2008, on average, 1.19 tons of CO_2 was emitted for every ton of steel produced. The industry's commitment to improving energy efficiency and CO_2 reduction has brought steelmaking processes to an advanced level. Thus, the industry continued its CO_2 Breakthrough Program, a partnership with leading universities designed to develop new ways of making steel while emitting little or no CO_2. Research would emphasize carbon sequestration technology and alternative energy approaches (Schorsch, 2008).

The U.S. steel industry has suggested putting carbon fees on imports of steel to the United States from any country, including China, that does not regulate greenhouse gas emissions to the same degree as is done in the United States (Gardner, 2009). According to the Alliance for American Manufacturing, the Chinese steelmaking industry emits two to three times as much CO_2 as the U.S. industry does. The Chinese expressed opposition to carbon tariff policies, which it said, would provoke a trade war and would violate World Trade Organization rules (Yap, 2009).

Production

Raw steel production in the United States was about 59.4 Mt in 2009, down about 35% from that in 2008 (table 1). The AISI estimated raw steel production capability to be 116 Mt, up slightly from that in 2008. Production represented 51.2% of estimated capacity, down from 81.4% in 2008.

Integrated steel producers smelted iron ores to make liquid iron in blast furnaces and used basic oxygen furnaces to refine the liquid iron with some steel scrap to produce raw liquid steel. The basic oxygen process was used to make 22.7 Mt of steel in the United States (American Iron and Steel Institute, 2010, p. 72). The use of this process decreased to 38.2% of total steel production in 2009 from 42.6% in 2008. Blast furnace operations in the United States were operated by 5 companies at 15 locations in 2009 (Iron and Steel Technology, 2010a, p. 230).

Minimills and specialty mills are nonintegrated steel producers that use the electric arc furnace (EAF) to melt low-cost raw materials (usually scrap). They also employ continuous casting machines and hot-rolling mills that are often closely coupled to casting operations. Specialty mills include producers of alloy-electrical, stainless, and tool steel; high-temperature alloys; forged ingots; and other low-volume steel products. About 93 companies operated about 112 EAF facilities in the United States during 2009 (Iron and Steel Technology, 2010b, p. 122). These U.S. mills used the EAF steelmaking process to produce 36.7 Mt of steel, a 30% decrease from that in 2008, and accounted for 61.8% of total steelmaking (American Iron and Steel Institute, 2010, p. 73).

Raw liquid steel is mostly cast into semifinished products in continuous casting machines. Only 2.5% of U.S. production was cast in ingot form in 2009, and subsequently rolled into semifinished forms, a slightly lower percentage than that of 2008. Continuous casting production was 57.9 Mt, or 97.5% of total steel production, slightly higher than in 2008 (American Iron and Steel Institute, 2010, p. 73).

During 2008 in the United States, 564 iron casting plants and 239 steel casting plants were operating (Modern Casting, 2009). U.S. casting production in 2008 for gray iron, ductile iron, malleable iron, and steel were 3.5 Mt, 3.6 Mt, 0.1 Mt, and 1.2 Mt, respectively. Casting production for gray iron, ductile iron, malleable iron, and steel decreased during 2008 compared with that of 2007 by 10%, 8%, 10%, and 6%, respectively.

Essar Steel Minnesota, LLC (a subsidiary of Essar Steel Ltd.) continued development of a low-grade iron ore open pit mine, concentrator, and pellet plant operation to supply a new direct reduced iron (DRI) plant. The new steel manufacturing facility was to include EAFs, thick slab casters, thin soft-reduction slab casters, and vacuum degassing/ladle treatment furnaces. This operation, located on the western end of the Mesabi Iron Range in northeastern Minnesota and adjacent to the community of Nashwauk, will be the first integrated mine through steelmaking facility in North America. Having all processes on one site was to minimize product movement and maximize energy savings.

Consumption

Steel mill products are produced at steel mills either by forging or rolling into forms normally delivered for fabrication or use. Some companies purchase semifinished steel mill products from other steel companies and use them to produce finished steel products. The accumulated shipments of all companies less the shipments to other reporting companies are identified as net shipments to avoid double counting.

U.S. apparent steel consumption, an indicator of economic growth, decreased to 63 Mt in 2009 from 102 Mt in 2008. Net shipments of steel mill products by U.S. companies decreased by 37% to 56.4 Mt compared with those of 2008 (American Iron and Steel Institute, 2010, p. 25). Compared with those in 2008, shipments of construction and contractors' products, the leading single end-use market of steel, decreased by 27% in 2009; automotive product shipments decreased by 37%; shipments of agricultural and industrial machinery, equipment, and tools decreased by 57%; steel service center shipments decreased by 40%; lumbering, mining, oil and gas, and quarrying industries shipments decreased by 62%; and shipments of appliances and containers, packaging, and shipping material decreased by 26% (American Iron and Steel Institute, 2010, p. 29).

Prices

The U.S. Department of Labor, Bureau of Labor Statistics (2010), producer price index for steel mill products decreased by 25% to 165.2 in 2009 from 220.6 in 2008 (1982 base=100) (table 1). The price of hot-rolled steel sheet decreased steadily from $509 per ton in January to a low of $380 per short ton in June, before increasing steadily to a high of $535 in September and October, and then decreasing to $500 per short ton in December (Purchasing Magazine, 2010).

Foreign Trade

Export shipments of steel mill products by AISI reporting companies decreased to 8.4 Mt from 12.2 Mt in 2008 (table 1). Canada received the largest amount of U.S. exported steel, 4.3 Mt, 32% less than in 2008 (table 4). Mexico was again the second leading importer, receiving 1.8 Mt, 31% less than in 2008. Imports of steel mill products decreased by 49% to 14.7 Mt from 29.0 Mt in 2008. Canada, China, the European Union (EU), Japan, the Republic of Korea, and Mexico, were major sources of steel mill product imports in 2009 (table 5).

Imports of semifinished steel (table 6) by steel companies are taken into consideration in evaluating apparent consumption (supply) of steel mill products in the United States and the share of the market represented by imported steel. To avoid double counting the imported semifinished steel and the products produced from it, the amount of semifinished steel consumed by companies that also produced raw steel are subtracted from domestic consumption. Between 1993 and 2006, semifinished steel imports ranged between 2.5 million metric tons per year (Mt/yr) and 8.5 Mt/yr. Prior to 1993, the amount was less than 0.2 Mt/yr. Taking the imported semifinished steel into consideration, the share of the U.S. steel market represented by imported steel was an estimated 25% in 2009 compared with 28% in 2008.

On December 30, 2009, the U.S. International Trade commission ruled unanimously in favor of U.S. steelmakers who were injured by high levels of unfairly traded oil country tubular goods into the U.S. market between 2006 and the middle of 2009 (American Iron and Steel Institute, 2009b). U.S. steelmakers had been advocates of complete and strict enforcement of laws against dumping and subsidized steel imports from China in order to maintain a viable U.S. manufacturing sector. China is said to have illegally spent more than $15 billion on energy subsidies for its steel industry in 2007 (New York Times, The, 2009).

At the beginning of 2009, a Buy America provision was added to the proposed $900 billion American Recovery and Reinvestment Act, which would require use of domestically produced steel in any government-funded infrastructure projects (Napsha, 2009). Supporters of this provision argued that in a time of severe economic recession, when the U.S. steel industry has cut output and laid off thousands of workers since mid-2007, the Government must curb imports from China, whose shipments of finished steel to the United States doubled in the second half of 2008. An estimated 77,000 new jobs would be created by the Buy American provision. Opponents of the provision claimed that only 1,000 new steel industry jobs would be created while as many as 65,000 jobs might be lost throughout the economy (Palmer, 2009). Debate also focused on the possibility that the Buy American provision would induce other countries to retaliate with trade restrictions that would adversely affect U.S. export activity (Smith, 2009).

Regarding the reporting of imports and exports (tables 4–6), "fabricated steel products" are those products produced from steel mill products but do not include products that incorporate steel products with other materials. Examples of fabricated steel products are structural steel and steel fasteners. "Other iron and steel products" refers to products that are not produced from steel mill products. Examples of other iron and steel products include iron or steel castings and DRI.

World Review

World production of pig iron totaled about 935 Mt, slightly more than that in 2008 (table 9). The pig iron production of the EU was about 77 Mt, 29% less than that in 2008. Germany was the leading producer in the EU, producing about 20 Mt, 31% less than that in 2008. China continued to be the leading producer of pig iron in the world, producing almost 544 Mt, 16% more than that of 2008. Japan, Russia, Brazil, the Republic of Korea, India, and the Ukraine, followed with 86 Mt, 44 Mt, 35 Mt, 30 Mt, 30 Mt, and 26 Mt, respectively. Russia and Ukraine were the only major pig iron producers in the Commonwealth of Independent States (CIS). In North America, the only major producer of pig iron was the United States, where production in 2009 decreased by 44% from that in 2008. In South America, the only major pig iron producer was Brazil.

World capacity for DRI production in 2009 was estimated to be about 82 Mt/yr (Midrex Technologies, Inc., 2010). DRI production worldwide was about 64 Mt in 2009, 3% less than that in 2008 (table 9). The leading producer of DRI was India, followed by, in descending order of tonnage, Iran, Venezuela, and Mexico. In 2009, additional DRI capacity of almost 20 Mt/yr was under construction in China, Egypt, India, Iran, Oman, Pakistan, the United Arab Emirates, and Venezuela. The leading technology was the Midrex process, followed by the HYL I and the HYL III processes.

World production of raw steel was 1.24 billion metric tons (Gt), 6% less than the revised production in 2008 (table 10). Steel production declined during 2009 in North America (33%), the EU (27%), the CIS (16%), and South America (2%). However, positive growth occurred in China (13%) and India (3%). China produced 46% of world total crude steel in 2009. As in previous years, production varied widely among major regions of the world. Asian countries produced about 65% of the world's steel; the EU, 12%; the CIS, 8%; and North America, 7%.

During 2009, China was again the world's leading steel producer, almost 568 Mt, a gain of 13% compared with that of 2008. In descending order of production, the leading producers behind China were Japan, the United States, Russia, India, and the Republic of Korea. These six countries accounted for 71% of world production. The combined steel production of the seven steel-producing countries in the CIS was about 97 Mt, a decrease of 16% from that in 2008. Russia and Ukraine remained the leading producers in the CIS. U.S. steel production during 2009 was 59.4 Mt, a decrease of 35% from that in 2008.

MEPS (International) Ltd. determined that the world steel capacity utilization was 74% during the first half of 2009. During 2009, world maximum steelmaking production potential was 1.68 Gt; also in 2009 steel capacity utilization in the Middle East, Asia, Africa, the CIS, South America, the EU, and North America, was 88%, 86%, 69%, 65%, 58%, 53%, and 50%, respectively (Steel-grips Online, 2009).

Outlook

The expansion or contraction of gross domestic product (GDP), the broadest measure of a nation's economic activity, may be considered a predictor of the health of the steelmaking and steel manufacturing industries, worldwide and domestically. The World Bank's forecast of global GDP growth for 2009, 2010, and 2011, was 2.2%, 2.7%, and 3.2%, respectively (World Bank, The, 2010). The International Monetary Fund's forecast of world GDP growth for 2009, 2010, and 2011 was -0.6%, 4.2%, and 4.3%, respectively (International Monetary Fund, 2010). The U.S. Federal Reserve's forecast for the U.S. 2009 GDP growth rate was between -1.5 and -1.0%, and between 2.1% and 3.3% for 2010 (U.S. Federal Reserve Bank, 2009). The 2009 GDP growth for China was 8.7%, and was projected to be 10% and 9.9% in 2010 and 2011, respectively, and that of India was 5.7%, 8.8%, and 8.4% for those years, respectively (International Monetary Fund, 2010, p. 2).

MEPS forecast total world steel production in 2010 to be 1,395 Mt, up 14% from that in 2009, and 1,625 Mt for 2014 [MEPS (International) Ltd., 2010]. MEPS also forecast increasing steel production in 2010 in the EU, South America, Asia, China, the CIS, and Africa of 22%, 13%, 12%, 10%, 8%, and 6%, respectively. For China, MEPS forecast a 31% increase in steel production by 2014 compared with that in 2009 (Locker Associates, 2010).

The progression of the U.S. financial downturn into a global economic downturn brought about a global decline of steel demand in late 2008 and throughout 2009. Improvement through 2010 will depend on the effects of government stimulation packages, stabilization of financial systems, and a return of consumer confidence.

World apparent steel consumption (ASC) was expected to increase by 11% to 1,241 Mt during 2010, after decreasing by 6.7% in 2009, and then increase by 5.3% in 2011, to reach a historic high of 1.3 Gt (World Steel Association, 2010). China's ASC was expected to increase by 6.7% to 579 Mt in 2010, and then by 2.8% in 2011. China was expected to account for 46% of world steel consumption. ASC in India was expected to increase by 14% in 2010 and 2011, respectively. The U.S. ASC was expected to increase by 27% in 2010, and by 7.5% in 2011. The EU's ASC was expected to increase by 14% in 2010 and increase by 7.9% in 2011. In Japan and the CIS, the 2010 ASC was expected to increase by 10% and 11%, respectively. Japan's ASC was expected to decrease slightly in 2011 while that of the CIS was expected to increase by 8%. Turkey's ASC was expected to increase by 13% in 2010 and 2011.

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TABLE 1
SALIENT IRON AND STEEL STATISTICS[1]

(Thousand metric tons)

	2005	2006	2007	2008	2009
United States:					
Pig iron:					
Production[2]	37,200	37,900	36,300	33,700	19,000
Exports[3]	51	813	71	51	11
Imports for consumption[3]	6,030	6,730	5,220	4,980	2,420
Direct-reduced iron:					
Production[4]	220	240	250	260	--
Exports[3]	--	(5)	(5)	(5)	(5)
Imports for consumption[3]	2,170	2,610	2,330	2,340 r	1,020
Raw steel production:[6]					
Carbon steel	85,900	89,500	89,800	84,100	55,100
Stainless steel	2,240	2,460	2,170	1,930	1,620
All other alloy steel	6,710	6,190	6,140	5,810	2,620
Total	94,900	98,200	98,100	91,800	59,400
Capability utilization, percent	87.5	87.5	87.0	81.4	51.2
Steel mill products:					
Net shipments[2]	95,200	99,300	96,500	89,400	56,400
Exports[2]	8,520	8,830	10,100	12,200	8,420
Imports[2]	29,100	41,100	30,200	29,000	14,700
Producer price index (1982=100.0)[7]	159.7	174.1	182.9	220.6	165.2
World production:[8]					
Pig iron	802,000	881,000	955,000 r	931,000 r	935,000
Direct-reduced iron[4]	56,300	58,800 r	64,700 r	66,500 r	64,500
Raw steel	1,140,000	1,250,000	1,350,000	1,330,000	1,240,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits, except producers price index; may not add to totals shown.

[2] Data are from the American Iron and Steel Institute (AISI).

[3] Data are from the U.S. Census Bureau.

[4] Data are from Midrex Technologies, Inc., government, and companies.

[5] Less than ½ unit.

[6] Raw steel is defined by AISI as steel in the first solid state after melting, suitable for rolling.

[7] Data are from the U.S. Department of Labor, Bureau of Labor Statistics.

[8] Data are from the U.S. Geological Survey and the World Steel Association.

TABLE 2

MATERIALS CONSUMED IN BLAST FURNACES AND PIG IRON PRODUCED[1]

(Thousand metric tons)

Material	2008	2009
Iron oxides:[2]		
Ores	--	--
Pellets	43,800	26,200
Sinter[3]	6,380	3,720
Total	50,100	29,900
Scrap[4]	2,630 r	1,460
Coke[2]	14,200	7,650
Pig iron, produced	33,700	19,000

rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] American Iron and Steel Institute.

[3] Includes sintered ore and pellet fines, dust, mill scale, and other revert iron-bearing materials; also some nodules.

[4] Mainly briquetted turnings and borings, shredded scrap, etc.; scrap produced at blast furnaces and remelt not included.

TABLE 3
DISTRIBUTION OF SHIPMENTS OF STEEL MILL PRODUCTS, BY STEEL TYPE, PRODUCT, AND MARKET[1]

	Quantity (thousand metric tons)		Percentage	
	2008	2009	2008	2009
Shipments by steel type:				
Carbon steel	83,400	53,000	93.29	93.97
Alloy steel	4,560	2,140	5.10	3.79
Stainless steel	1,380	1,200	1.54	2.13
Total	89,400	56,400	100.00	100.00
Steel mill products:				
Ingots, blooms, billets and slabs	1,120	801	1.25	1.42
Wire rods	2,100	1,490	2.35	2.64
Structural shapes, heavy	6,040	3,380	6.76	5.99
Steel piling	462	382	0.52	0.68
Plates, cut lengths	6,730	4,100	7.53	7.27
Plates, in coils	3,170	2,110	3.55	3.74
Rails	854	712	0.96	1.26
Railroad accessories	247	190	0.28	0.34
Bars, hot-rolled	6,710	3,100	7.51	5.50
Bars, light-shaped	1,600	1,090	1.79	1.93
Bars, reinforcing	7,010	4,610	7.84	8.17
Bars, cold finished	1,490	827	1.67	1.47
Tool steel	16	7	0.02	0.01
Pipe and tubing, standard pipe	919	535	1.03	0.95
Pipe and tubing, oil country goods	2,170	945	2.43	1.68
Pipe and tubing, line pipe	432	169	0.48	0.30
Pipe and tubing, mechanical tubing	821	387	0.92	0.69
Pipe and tubing, pressure tubing	47	22	0.05	0.04
Pipe and tubing, stainless	13	9	0.01	0.02
Pipe and tubing, structural	112	62	0.13	0.11
Pipe for piling	14	0	0.02	0.00
Wire	564	288	0.63	0.51
Tin mill products, blackplate	202	62	0.23	0.11
Tin mill products, tinplate	1,610	1,580	1.80	2.80
Tin mill products, tin-free steel	526	453	0.59	0.80
Tin mill products, tin coated sheets	91	66	0.10	0.12
Sheets, hot-rolled	17,800	12,100	19.91	21.45
Sheets, cold-rolled	10,300	6,780	11.52	12.02
Sheets and strip, hot dip galvanized	11,600	7,350	12.98	13.03
Sheets and strip, electrogalvanized	1,500	1,020	1.68	1.81
Sheets and strip, other metallic coated	1,220	654	1.36	1.16
Sheets and strip, electrical	481	326	0.54	0.58
Strip, hot rolled	39	28	0.04	0.05
Strip, cold rolled	1,340	693	1.50	1.23
Total	89,400	56,400	100.00	100.00
Shipments by markets:				
Service centers and distributors	23,100	13,800	25.84	24.47
Construction	18,500	13,500	20.69	23.94
Automotive	11,700	7,300	13.09	12.94
Machinery	1,040	642	1.16	1.14
Containers	2,560	2,040	2.86	3.62
All others	32,500	19,200	36.35	34.04
Total	89,400	56,400	100.00	100.00

[1] Data are rounded to no more than three significant digits, except percentages; may not add to totals shown.

Source: American Iron and Steel Institute.

TABLE 4

U.S. IMPORTS AND EXPORTS OF STEEL MILL PRODUCTS, BY COUNTRY[1]

(Thousand metric tons)

Country	2008		2009	
	Imports	Exports	Imports	Exports
Argentina	129	12	75	74
Australia	636	33	258	15
Brazil	1,200	318	654	135
Canada	6,430	6,290	3,880	4,270
China	4,380	263	1,330	194
European Union[2]	2,620	653	1,760	278
Germany	1,080	85	450	43
Japan	1,600	32	1,110	13
Korea, Republic of	2,090	92	1,200	55
Mexico	2,900	2,670	1,590	1,840
Russia	1,020	--	492	--
South Africa	81	16	30	9
Sweden	255	10	150	61
Taiwan	600	56	336	92
Turkey	750	--	446	--
Ukraine	1,260	--	46	--
Venezuela	38	118	69	66
Other	1,900	1,570	839	1,280
Total	29,000	12,200	14,700	8,420

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes Germany and Sweden.

Source: American Iron and Steel Institute.

TABLE 5

U.S. EXPORTS OF IRON AND STEEL PRODUCTS[1]

(Thousand metric tons)

	2008	2009
Steel mill products:		
Ingots, blooms, billets, slabs	517	589
Wire rods	139	144
Structural shapes, heavy	1,140	515
Steel piling	44	30
Plates, cut lengths	1,350	813
Plates, in coils	1,020	703
Rails, standard	86	88
Rails, other	31	29
Railroad accessories	60	14
Bars, hot-rolled	722	390
Bars, light-shaped	136	92
Bars, concrete reinforcing	629	390
Bars, cold-finished	190	109
Tool steel	18	13
Pipe and tubing, standard pipe	193	74
Pipe and tubing, oil country goods	419	273
Pipe and tubing, line pipe	382	198
Pipe and tubing, mechanical tubing	49	37
Pipe and tubing, stainless	44	29
Pipe and tubing, nonclassified	438	309
Pipe and tubing, structural	197	181
Pipe for piling	66	25
Wire	199	143
Tin mill products, blackplate	5	3
Tin mill products, tinplate	241	220
Tin mill products, tin-free steel	24	13
Sheets, hot-rolled	958	717
Sheets, cold-rolled	788	582
Sheets and strip, hot-dip galvanized	896	726
Sheets and strip, electrogalvanized	279	290
Sheets and strip, other metallic coated	296	174
Sheets and strip, electrical	278	205
Strip, hot-rolled	205	157
Strip, cold-rolled	190	144
Total	12,200	8,420
Fabricated steel products:		
Structural shapes, fabricated	529	319
Rails, used	51	34
Railroad products	100	41
Wire rope	21	18
Wire, stranded products	43	31
Wire, other products	88	85
Springs	129	100
Nails and staples	37	27
Fasteners	625	678
Chains and parts	34	28
Grinding balls	92	83

See footnotes at end of table.

TABLE 5—Continued

U.S. EXPORTS OF IRON AND STEEL PRODUCTS[1]

(Thousand metric tons)

	2008	2009
Cast iron and steel products:		
Pipe and tube fittings	42	27
Other[2]	112	84
Total	1,900	1,560
Grand total	14,100	9,970
Cast steel pipe fittings	46	27
Cast iron pipe and fittings	120	101
Cast steel rolls	4	2
Cast grinding balls	18	27
Granules, shot and grit	34	26
Other castings	82	55
Total	304	238

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes shapes cold formed, sashes and frames, fence and sign post, architectural and ornamental work, and conduit.

Source: American Iron and Steel Institute.

TABLE 6
U.S. IMPORTS OF MAJOR IRON AND STEEL PRODUCTS[1]

(Thousand metric tons)

	2008	2009
Steel mill products:		
Ingots, blooms, billets, and slabs	5,420	1,850
Wire rods	1,120	692
Structural shapes-heavy	655	337
Steel piling	95	49
Plates, cut lengths	1,120	481
Plates, in coils	1,100	645
Rails and railroad accessories	305	259
Bars, hot-rolled	1,350	612
Bars, light-shaped	151	78
Bars, reinforcing	881	380
Bars, cold-finished	283	169
Tool steel	148	52
Pipe and tubing, standard pipe	1,070	538
Pipe and tubing, oil country goods	3,610	1,450
Pipe and tubing, line pipe	2,920	1,450
Pipe and tubing, mechanical tubing	551	302
Pipe and tubing, pressure tubing	128	57
Pipe and tubing, stainless	127	81
Pipe and tubing, nonclassified	15	13
Pipe and tubing, structural	442	231
Pipe for piling	17	14
Wire	643	441
Tin mill products-blackplate	21	38
Tin mill products-tinplate	291	293
Tin mill products-tin-free steel	96	78
Sheets, hot-rolled	2,510	1,580
Sheets, cold-rolled	1,310	1,030
Sheets and strip, hot-dip galvanized	1,650	937
Sheets and strip, electrogalvanized	170	85
Sheets and strip, other metallic coated	455	270
Sheets and strip, electrical	110	60
Strip, hot-rolled	44	41
Strip, cold-rolled	158	112
Total	29,000	14,700
Fabricated steel products:		
Structural shapes, fabricated	1,440	965
Rails, used	73	57
Railroad products	198 [r]	97
Wire rope	141	113
Wire-stranded products	329	158
Springs	310	214
Nails and staples	589	388
Fasteners	1,330	779
Chains and parts	150	98
Pipe and tube fittings	307	203
Other	366 [r]	456
Total	5,220 [r]	3,530
Grand total	34,200 [r]	18,200

See footnotes at end of table.

TABLE 6—Continued

U.S. IMPORTS OF MAJOR IRON AND STEEL PRODUCTS[1]

(Thousand metric tons)

	2008	2009
Cast iron and steel products:		
Cast steel pipe fittings	307	203
Cast iron pipe and fittings	71	35
Other products	399	226
Total	777	464

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: American Iron and Steel Institute.

TABLE 7

U.S. IMPORTS OF STAINLESS STEEL[1]

(Metric tons)

Product	2008	2009
Semifinished	124,000	70,200
Plate	84,800	46,800
Sheet and strip	72,100	36,000
Bars and shapes	116,000	69,900
Wire and wire rods	62,400	40,700
Pipe and tube	127,000	81,300
Total	586,000	345,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: American Iron and Steel Institute.

TABLE 8

COAL AND COKE AT COKE PLANTS[1, 2]

(Thousand metric tons)

	2008	2009
Coal, consumption	20,000	13,900
Coke:[3]		
Production	14,200	10,100
Exports	1,780	1,190
Imports	3,270	315
Consumption, apparent	15,400	9,360

[1] Data are rounded to no more than three significant digits.

[2] Includes furnace and merchant coke plants.

[3] Coke production and consumption do not include breeze.

Source: Energy Information Administration, Quarterly Coal Report, DOE/EIA-0121(2010/01Q).

TABLE 9

PIG IRON AND DIRECT-REDUCED IRON: WORLD PRODUCTION, BY COUNTRY[1, 2, 3, 4]

(Thousand metric tons)

Country[5]	2005	2006	2007	2008	2009
Algeria	952 [e]	1,093	1,193	690 [e]	458
Argentina:					
Pig iron	2,646	2,481	2,593	1,847 [r]	807
Direct-reduced iron	1,823	1,947	1,810	2,581 [r]	2,042
Australia	6,203	6,276	6,351	6,409 [r]	4,400 [e]
Austria	5,444	5,547	5,808	5,795 [r]	4,562 [p]
Belgium	7,254	7,516	6,576	7,125 [r]	3,087
Bosnia and Herzegovina[e]	60	60	60	243 [6]	483 [6]
Brazil:					
Pig iron	33,884	32,452	35,571	35,286 [r]	35,300 [p]
Direct-reduced iron[e]	411	376	362	302	305 [p]
Bulgaria	1,081	1,147	1,069	441	--
Burma:[e]					
Pig iron	2	2	2	2	2
Direct-reduced iron	40	40	40	40	40
Canada:					
Pig iron	8,274	8,305	8,577	9,000 [e]	5,000 [e]
Direct-reduced iron	591	446	910	690 [e]	300 [e]
Chile	1,074	1,115	1,147	1,109 [r]	920 [e]
China[7]	343,750	412,450	476,520	470,670	543,750
Colombia	325	360 [r]	341 [r]	300 [r]	324
Czech Republic	4,627	5,191	5,289	4,737	3,483
Egypt:					
Pig iron	1,100	1,100	1,000	1,000	600
Direct-reduced iron[e]	2,900	3,100	2,786 [6]	3,000	2,900
Finland	3,056	3,158	2,914	2,900 [e]	2,800
France	12,705	13,013	12,426	11,372 [r]	8,105
Germany:					
Pig iron	28,854	30,360	31,149	29,111	20,127 [p]
Direct-reduced iron[e]	440	580	590	520 [r]	380 [p]
Hungary	1,329	1,335	1,394	1,289	1,050
India:					
Pig iron	27,125	28,300	28,800	29,000 [e]	29,500
Direct-reduced iron	12,040	14,740	18,100	20,200 [e]	21,000
Indonesia, direct-reduced iron[e]	1,390	1,290 [6]	1,420 [r]	1,290 [r]	1,300
Iran:					
Pig iron	2,300	2,041	2,118	2,200 [e]	2,500 [e]
Direct-reduced iron[e]	6,850	6,850	7,440	7,460	8,000
Italy	11,423	11,497 [r]	11,110 [r]	10,373 [r]	5,719
Japan	83,058	84,270	86,771	86,171	86,000 [e]
Kazakhstan	3,581	3,400	3,240	2,761	2,700 [e]
Korea, North[e]	900 [6]	900	900	900	900
Korea, Republic of	27,309	27,559	29,437	31,043	30,000 [e]
Libya, direct-reduced iron	1,669	1,633	1,660	1,569	1,097
Malaysia, direct-reduced iron	1,349	1,277	1,840	1,957 [r]	2,000 [e]
Mexico:					
Pig iron	4,047	3,800	4,077	4,670 [r]	3,929
Direct-reduced iron	5,973	6,167	6,265	5,940 [r]	4,203
Morocco[e]	15	15	15	15	15
Netherlands[8]	6,031	5,417	6,412 [r]	6,130 [r]	4,655
New Zealand[e]	652	664	679	622 [r]	608
Nigeria	--	150	200	--	-- [e]

See footnotes at end of table.

TABLE 9—Continued
PIG IRON AND DIRECT-REDUCED IRON: WORLD PRODUCTION, BY COUNTRY[1, 2, 3, 4]

(Thousand metric tons)

Country[5]	2005	2006	2007	2008	2009
Norway[e]	100	100	100	100	100
Pakistan[e]	1,500	1,200	1,000	1,000	1,000
Paraguay	124	136	148[r]	145[r]	146[p]
Peru:[e]					
Pig iron	263	306	351[6]	395[6]	400[p]
Direct-reduced iron	78	84	90	72	75
Poland	4,477	5,333	5,804	4,934	3,015
Portugal[e]	100	100	100	100	100
Qatar, direct-reduced iron	820	880	1,200	1,700[e]	2,100
Romania	4,098	3,946	3,923	2,945[r]	1,611
Russia:					
Pig iron	49,175	51,683	51,523	48,300	43,930
Direct-reduced iron[e]	3,340	3,340	4,000	4,000	4,000
Saudi Arabia, direct-reduced iron	3,630[e]	3,580	4,340	4,970	5,000[e]
Serbia	1,115[9]	1,529	1,485	1,582	1,006
Slovakia	3,618	4,145	4,012	3,529	3,019
South Africa:					
Pig iron	6,130	6,159	5,358	5,350[r]	4,376
Direct-reduced iron	1,781	1,754	1,736	1,190	1,386
Spain	4,160	3,432	3,974	3,995	3,995[e]
Sweden	3,730	3,577	3,815	3,800[e]	3,700
Taiwan	9,854	10,500	10,550	9,750[r]	7,939
Trinidad and Tobago, direct-reduced iron	2,055	2,072[r]	2,065[r]	1,600[r]	1,182
Turkey	5,970	5,952	6,234	6,600[e]	7,000[e]
Ukraine	30,747	32,926	35,647	30,982	25,676
United Kingdom	10,236	10,736	10,960	10,137[r]	7,674
United States:					
Pig iron	37,200	37,900	36,300	33,700	19,000
Direct-reduced iron	220	240	250	260	--
Venezuela, direct-reduced iron	8,897	8,400	7,782	7,140	7,150[p]
Zimbabwe[e]	129	38	--	--	--
Grand total	858,000	939,000	1,020,000	997,000[r]	1,000,000
Of which:					
Pig iron[10]	802,000	881,000	955,000[r]	931,000[r]	935,000
Direct-reduced iron[11]	56,300	58,800[r]	64,700[r]	66,500[r]	64,500

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Production is pig iron unless otherwise specified.

[3] Direct-reduced iron is obtained from ore by reduction of oxides to metal without melting.

[4] Table excludes ferroalloy production except where otherwise noted. Table includes data available through August 25, 2010.

[5] In addition to the countries listed, Vietnam has facilities to produce pig iron and may have produced limited quantities during 2005–09, but output is not reported and available information is inadequate to make reliable estimates of output levels.

[6] Reported figure.

[7] Figures reported by State Statistical Bureau that the Government of China considers to be official statistical data.

[8] Includes blast furnace ferroalloys.

[9] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[10] Includes unspecified pig iron and direct-reduced iron.

[11] Listed separately.

TABLE 10

RAW STEEL: WORLD PRODUCTION, BY COUNTRY[1,2,3]

(Thousand metric tons)

Country[4]	2005	2006	2007	2008	2009
Albania	180	206	263	380[r]	440
Algeria	1,007	1,158	1,278	646	458
Argentina	5,386	5,533	5,387	5,441[r]	4,014
Australia	7,788	7,937	8,047	7,724[r]	6,135
Austria	7,031	7,129	7,578	7,594[r]	5,662[p]
Azerbaijan	286	54	273	300[e]	200[e]
Bangladesh[e,5]	20	10	--[6]	--	--
Belarus	2,076	2,100	2,214	2,660	2,330
Belgium	8,906	11,238	10,692	10,676[r]	5,636
Bosnia and Herzegovina, ingot production	289[r]	490[r]	533[r]	608[r]	519
Brazil[7]	31,631	30,901	33,782	33,716[r]	33,750[p]
Bulgaria	1,969	2,124	1,909	1,330	726
Burma[e]	25	25	25	25	25
Canada	15,327	15,493	15,569	15,100	9,000[e]
Chile[7]	1,537	1,627	1,679	1,523[r]	1,302
China[8]	353,240	419,150	489,290	500,490	567,840
Colombia	842[e]	1,221	1,245[r]	1,053[r]	1,079
Croatia	74	81	76	115[r,e]	52[e]
Cuba	245	257	262	274	274[e]
Czech Republic	6,189	6,862	7,059	6,387[r]	4,594
Ecuador	84	85	87	85[e]	85[e]
Egypt	5,603	6,045	6,224	6,198	5,508
El Salvador	48	72	73	72[e]	72[e]
Ethiopia, all from scrap[e]	60	60	110	150	150
Finland	4,738	5,052	4,431	4,418[r]	3,078
France	19,481	19,857	19,252	17,874	12,836
Germany	44,524	47,224	48,550	45,833	32,671[p]
Ghana, all from scrap[e]	25	25	25	--[r]	--
Greece	2,266	2,416	2,554	2,400[e]	2,082
Guatemala	207	292	349	250[r]	224
Hong Kong[e]	500	550	550	550	550
Hungary	2,005	2,144	2,317	2,160[r]	1,401
India	45,800	49,500	53,100	55,200	56,600
Indonesia	3,675	3,759	4,160[r]	3,915[r]	3,500[e]
Iran	9,405	9,789	10,051	9,960[e]	10,000[e]
Israel[e]	480	480	480	480	430
Italy	29,061	31,550	31,990	30,477	19,737
Japan	112,471	116,266	120,203	118,739	87,500
Jordan[e]	150	150	150	150	150
Kazakhstan	4,477	4,245	4,784	4,244[r]	4,147
Korea, North[e]	1,070	1,180	1,230	1,279[6]	1,300
Korea, Republic of	47,820	48,455	51,517	53,322	53,300[e]
Latvia[e]	550	550	550	550	550
Libya	1,255	1,151	1,151	1,137	914
Luxembourg	2,194	2,802	2,858[r]	2,582[r]	2,215
Macedonia	326	360	372	252[r]	278[e]
Malaysia	5,296	5,834	6,895	6,423[r]	6,600[e]
Mauritania	1	1	1	2	2[e]
Mexico	16,202	16,313	17,573	17,209[r]	14,172

See footnotes at end of table.

TABLE 10—Continued
RAW STEEL: WORLD PRODUCTION, BY COUNTRY[1, 2, 3]

(Thousand metric tons)

Country[4]	2005	2006	2007	2008	2009
Moldova	1,016	675	995	885	425
Montenegro	104 [9]	163	174	202 [r]	50 [e]
Morocco	205	314	314	478 [r]	480
Netherlands	6,919	6,372	7,368 [r]	6,853 [r]	5,194
New Zealand	889	862	845	853	800 [e]
Norway[e]	701	679	680	590 [r]	591 [6]
Pakistan	825	1,040	1,090	1,100	1,100 [e]
Paraguay	101	118 [r]	132 [r]	130 [r]	130 [p, e]
Peru	790	896	881	1,150 [e]	1,200 [e]
Philippines	470	558	718	711 [r]	700 [e]
Poland	8,336	9,992	10,621	9,727	7,208
Portugal	1,400 [6]	1,400	1,400	1,400	1,400
Qatar	1,057	1,003	1,147	1,406	1,028
Romania	5,632	6,266	6,261	5,035	2,699
Russia	66,186	70,816	72,389	68,700	59,166
Saudi Arabia	4,185	3,974	4,644	4,670 [e]	4,700 [e]
Serbia	1,286 [9]	1,837	1,478	1,662	1,097
Singapore[e]	572	607	620	600	620
Slovakia	4,547 [r]	5,094 [r]	5,100 [r]	4,489 [r]	3,747
Slovenia	583	627	638	642 [r]	436
South Africa	9,494	9,718	9,098	8,269 [r]	7,484
Spain	17,826	18,391	18,999	19,048	19,100 [p, e]
Sri Lanka[e]	30	30	30	30	30
Sweden	5,692	5,435	5,673	5,500 [e]	5,000 [e]
Switzerland	1,158	1,252	1,264	1,260	981
Syria[e]	70	70	70	70 [r, 6]	70
Taiwan	18,567	19,203	20,883	19,222	15,566
Thailand	5,161	5,210	5,470	5,470 [e]	5,470 [e]
Trinidad and Tobago	711	674	682	675 [e]	675 [e]
Tunisia	66	68	61	82 [r]	155
Turkey	20,960	23,308	25,750	26,400 [e]	25,000 [e]
Uganda	30	30	30	30	25
Ukraine	38,636	40,899	42,830	37,107	29,757
United Arab Emirates[e]	70	70	90	90	90
United Kingdom	13,210	13,931	14,300	13,538	10,080 [p]
United States	94,900	98,200	98,100	91,900	59,400
Uruguay	64	57	71	70 [r]	70 [p, e]
Uzbekistan[e]	607	730 [e]	740 [e]	686 [r]	716
Venezuela	4,907	4,864	5,005	4,240	5,000 [p, e]
Vietnam	890	1,869 [r]	2,024	2,250 [r]	2,250 [e]
Zimbabwe	107	24	23	10 [e]	10 [e]
Total	1,140,000	1,250,000	1,350,000	1,330,000	1,240,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 10—Continued

RAW STEEL: WORLD PRODUCTION, BY COUNTRY[1, 2, 3]

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[2] Steel formed in solid state after melting, suitable for further processing or sale; for some countries, includes material reported as "liquid steel," presumably measured in the molten state prior to cooling in any specific form.

[3] Table includes data available through September 8, 2010.

[4] In addition to the countries listed, Mozambique is known to have steelmaking plants, but available information is inadequate to make reliable estimates of output levels.

[5] Data for year ending June 30 of that stated.

[6] Reported figure.

[7] Excludes castings.

[8] Figures reported by the State Statistical Bureau that the Government of China considers as official statistical data.

[9] Montenegro and Serbia formally declared independence from each other in June 2006 and dissolved their union. Production is reported individually now.

IRON AND STEEL SCRAP

By Michael D. Fenton

Domestic survey data and tables were prepared by Hoa P. Phamdang, statistical assistant.

Iron and steel scrap is a vital raw material for the production of new steel and cast-iron products. The steelmaking and foundry industries in the United States are highly dependent upon the ready availability of scrap from manufacturing operations and from the recovery of products that are no longer used or needed. The steel industry has been recycling steel scrap for more than 170 years, using electric arc furnaces (EAF), which accounted for about 62% of the total raw steel produced in 2009. Consistent with international usage and Federal Government policy, the U.S. Geological Survey (USGS) reports all data on iron and steel in metric units, unless otherwise noted.

Steel scrap recycling conserves energy, landfill space, and raw materials. In 2009, the domestic steel industry recycled or exported for recycling more than 59 million metric tons (Mt) of appliances, automobiles, cans, construction materials, and other steel products (Bill Heenan, Steel Recycling Institute, unpub. data, January 4, 2011). This resulted in an overall recycling rate of greater than 103%. This record-high recycling rate was not only attributed to the collection of steel scrap, but also to the reduced production of new steel for consumer products caused by the recession of 2009. The remelting of scrap requires much less energy than does the production of iron and steel products from iron ore. Each year, steel recycling saves the energy equivalent of the electrical power needed for 1 year by approximately one-fifth of the houses in the United States (about 18 million houses). Consumption of iron and steel scrap by remelting reduces the burden on landfill disposal facilities and prevents the accumulation of abandoned steel products in the environment.

In the United States, the primary source of obsolete steel is the automobile. By weight, the typical car consists of about 65% iron and steel. The steel used in car bodies is made of about 25% recycled steel (Steel Recycling Institute, 2010a). The steel industry recovered and recycled more than 14 Mt of iron and steel from end-of-life vehicles in 2009. The recycling rate for automotive scrap was 140% in 2009. A recycling rate greater than 100% is a result of the steel industry recycling more steel from automobiles than was used in the production of new vehicles.

The annual average recycling rate of obsolete appliance scrap continued at a high of 90% in 2009, the same as that of 2008, compared with 20% in 1988 (Bill Heenan, President, Steel Recycling Institute, unpub. data, November 15, 2010). During 2009, about 2.5 Mt of steel was recovered from recycled appliances, a decrease of about 15% compared with that of 2008. The typical appliance consists of about 75% steel, and the steel used in appliances is made with a minimum of 25% recycled steel (Steel Recycling Institute, 2010b). The recycling rate of steel containers increased to more than 66% in 2009 from 15% in 1983 (Bill Heenan, Steel Recycling Institute, unpub. data, January 4, 2011). More than 1.3 Mt of steel containers were recycled. The estimated rate of recycling of structural beams and plates in 2004 through 2009 was about 98%, an increase from 85% in 1997. Recycling rates for reinforcement bar and other materials increased to 70% in 2009 from 40% in 1997.

Minimills, in which EAFs are used, consumed direct-reduced iron (DRI) to improve steel quality, and integrated steelmakers continued to use small quantities of DRI in blast furnaces as a process coolant. Minimills often used a feed mix that has equal proportions of DRI, pig iron, and scrap. Raw steel production in the minimill industry decreased by 30% during 2009 (American Iron and Steel Institute, 2010, p. 72; table 3), and DRI production decreased to zero, compared with those in 2008 (Midrex Technologies, 2009).

Consumption

Domestic data for ferrous scrap were derived from voluntary monthly or annual surveys of U.S. scrap-consuming operations by the USGS. About 49% of the known manufacturers of pig iron and raw steel responded to the surveys. Their responses represented about 52% of estimated total scrap consumption by this class of consumers. The remaining 48% of scrap consumption was estimated based on prior reports. Of the iron foundries, manufacturers of steel castings, and miscellaneous users, about 56% of the surveyed establishments responded to the annual survey, which represented about 40% of estimated scrap consumption by this class of consumers. Total consumption for these two classes of consumers was estimated using statistical methods and prior reports. Actual survey data accounted for about 40% of total estimated scrap consumption by all classes of scrap consumers.

In 2009, brokers, dealers, and other outside sources supplied domestic consumers with 43.4 Mt of all types of ferrous scrap at an estimated average delivered value of $9.01 billion, and exported 22.4 Mt (excluding used rails for rerolling and other uses, and ships, boats, and other vessels for scrapping) valued at $7.1 billion (tables 1, 8, and 11). Raw steel production was 59.4 Mt in 2009 compared with 91.9 Mt in 2008 (American Iron and Steel Institute, 2010, p. 73). The share of raw steel produced by EAF and basic oxygen furnaces was 62% and 38%, respectively. In 2009, continuous cast steel production represented 98% of total raw steel production; this was slightly greater than that of 2008. Raw steel production capability increased to 116 Mt from 113 MT in 2008 (American Iron and Steel Institute, 2010, p. 75.). The capability utilization index decreased from 81.4% in 2008 to 51.2% in 2009.

Steel mills accounted for 92% of all scrap received from brokers, dealers, and other outside sources; iron foundries and miscellaneous users received 7%; and steel foundries received 1% (table 1). Apparent total domestic consumption of ferrous scrap was 40.2 Mt, as measured by net receipts (total external receipts minus shipments) and 9.4 Mt of home scrap (table 2).

Stocks of ferrous scrap at consumer plants decreased by 26% to 3.4 Mt (table 1). Total domestic consumption was 53.1 Mt, 21% less than that of 2008 (table 1). The total market for U.S.-produced scrap (net receipts plus exports minus imports) was 62.8 Mt, compared with 74.2 Mt in 2008 (table 1). Feedstock used in electric furnaces by all iron and steel product manufacturers comprised scrap, 90%; pig iron, 9%; and DRI, 1% (table 4). Total consumption of DRI was 31% less than that of 2008 (table 1). Net shipments of all grades of steel mill products were about 56.4 Mt, which was a decrease of 37% from the 89.3 Mt shipped in 2008 (American Iron and Steel Institute, 2010, p. 25).

Prices

The average composite delivered price of No. 1 heavy-melting steel scrap in 2009, calculated from prices per long ton published monthly by American Metal Market, was $207.58 per metric ton. The price ranged from a low of $146.74 per ton in April to a high of $257.06 per ton in September (table 8). The average composite delivered price of No. 1 heavy-melting steel scrap, calculated from prices per long ton published weekly in the Iron Age Scrap Price Bulletin, was $204.21 per metric ton; the price ranged from a low of $141.32 per ton in April to a high of $252.37 per ton in September.

Based on weekly quotations by Iron Age Scrap Price Bulletin for 18–8 (18% chromium, 8% nickel) stainless steel scrap (bundles and solids) delivered to consumers in the Pittsburgh, PA, area, the average price in 2009 was about $1,547 per gross ton, a decrease of 35% compared with that of 2008.

The unit value of total ferrous scrap exports (excluding used rails for rerolling and other uses, and ships, boats, and other vessels for scrapping) decreased by 34% to about $318 per metric ton compared with that of 2008 (table 11). The unit value of total imports decreased by 33% to about $273 per metric ton, compared with that of 2008 (table 14).

Foreign Trade

Foreign trade valuation continued to be reported on a free-alongside-ship basis for exports and on a customs-value basis for imports. In 2009, the U.S. trade surplus for all classes of ferrous scrap (including used rails for rerolling and other uses, and ships, boats, and other vessels for scrapping) was 19.4 Mt valued at about $6.3 billion (tables 11, 14). This represented an increase of about 9% in quantity and a decrease of 29% in value compared with the 2008 surplus of 17.9 Mt valued at $8.9 billion.

World Review

Iron and steel scrap is an important raw material for the steel and foundry industries. Because scrap comes from such sources as discarded cars and consumer durables, industrial machinery, manufacturing operations, and old buildings, the relatively mature industrialized economies are generally the main exporters of scrap to lesser developed steelmaking countries.

The United States exported more iron and steel scrap in 2009 than any other country, followed by, in decreasing order of export tonnage, Japan, Germany, the United Kingdom, and France (World Steel Association, 2010a, p. 115–116). The leading importing nations were, in decreasing order of import tonnage, Turkey, China, the Republic of Korea, India, and Spain (World Steel Association, 2010a, p. 117).

Outlook

Because of the close interdependence of the steelmaking and ferrous scrap industries, forecast of the global steel industry in the context of the global economy serves as the bellwether of the scrap industry.

The World Bank's forecast of global GDP growth for 2010 and 2011 was 2.7% and 3.2%, respectively (World Bank, The, 2010). The International Monetary Fund's forecast of world GDP growth for 2010 and 2011 was 4.2% and 4.3%, respectively (International Monetary Fund, 2010). The U.S. Federal Reserve Bank's forecast for the U.S. 2010 GDP growth rate was between 2.1% and 3.3% (U.S. Federal Reserve Bank, 2009). The GDP growth for China was projected to be 10% and 9.9% in 2010 and 2011, respectively, and that of India was 8.8% and 8.4% for those years, respectively (International Monetary Fund, 2010).

World apparent steel consumption (ASC) was expected to increase by 11% to 1,241 Mt during 2010 and then increase by 5.3% in 2011, to reach a historic high of 1.3 billion tons. China's ASC was expected to increase by 6.7% to 579 Mt in 2010, and then by 2.8% in 2011. China was expected to account for 46% of world steel consumption in 2010. ASC in India was expected to grow by 14% in both 2010 and 2011. The United States ASC was expected to increase by 27% in 2010, and then by 7.5% in 2011. The European Union (EU) ASC was expected to increase by 14% in 2010 and increase by 7.9% in 2011. In Japan and the Commonwealth of Independent States (CIS), the 2010 ASC was expected to increase by 10% and 11%, respectively. Japan's ASC was expected to decrease slightly in 2011, while that of the CIS was expected to increase by 8%. Turkey's ASC was expected to increase by 13% in both 2010 and 2011(World Steel Association, 2010b).

World capacity for DRI production in 2009 was estimated to be almost 75 million metric tons per year (Mt/yr). In 2009, additional DRI capacity of almost 17 Mt/yr was under construction in China, Egypt, India, Iran, Oman, Pakistan, the United Arab Emirates, and Venezuela (Midrex Technologies, Inc., 2010).

MEPS (International) Inc. (2010) forecast total world steel production in 2010 to be 1,395 Mt, up 14% from that in 2009, and 1,625 Mt for 2014. MEPS also forecast increasing steel production in 2010 in the EU, South America, Asia (excluding China), China, the CIS, and Africa of 22%, 13%, 12%, 10%, 8%, and 6%, respectively. For China, MEPS forecast a 31% increase in steel production by 2014 compared with that in 2009.

Because the primary source of obsolete steel is the automobile, an increasing world population and increased demand for vehicles in developing countries, especially China and India, are expected to contribute to a dramatic rise in the amount of vehicle scrap created during the next 25 years, according to the Oxford Brookes University in the United Kingdom (Blanco, 2007). More vehicles are expected to be produced in the next 25 years than in the history of the motor vehicle industry through 2008.

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TABLE 1

SALIENT U.S. IRON AND STEEL SCRAP, PIG IRON, AND DIRECT-REDUCED IRON STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2005	2006	2007	2008	2009
Manufacturers of pig iron and raw steel and castings:[2]					
Ferrous scrap consumption	55,000	54,500	54,600	57,600 r	47,600
Pig iron consumption	36,900	36,700	36,500	33,600 r	28,300
Direct-reduced iron consumption	1,740	1,530	2,040	1,950	1,340
Net receipts of ferrous scrap[3]	43,600	45,300	46,400	49,400 r	39,800
Home scrap production[4]	11,400	9,120	8,700	8,650 r	7,570
Ending stocks of ferrous scrap, December 31	4,430	3,870	3,620	3,700 r	2,820
Manufacturers of steel castings:[5]					
Ferrous scrap consumption	1,060	1,080	1,700	2,080 r	838
Pig iron consumption	36	11	11	12 r	17
Direct-reduced iron consumption	--	--	--	4	14
Net receipts of ferrous scrap[3]	713	754	965	1,630 r	586
Home scrap production[4]	333	319	692	549 r	271
Ending stocks of ferrous scrap, December 31	85	79	383	503 r	397

See footnotes at end of table.

TABLE 1—Continued

SALIENT U.S. IRON AND STEEL SCRAP, PIG IRON, AND DIRECT-REDUCED IRON STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2005	2006	2007	2008	2009
Iron foundries and miscellaneous users:[5]					
Ferrous scrap consumption	9,540	8,300	7,940	7,770 r	4,640
Pig iron consumption	1,140	937	877	846 r	1,850
Direct-reduced iron consumption	3	4	4	3 r	4
Net receipts of ferrous scrap[3]	6,460	5,610	5,130	5,200	2,970
Home scrap production[4]	3,280	2,700	2,550	2,560 r	1,720
Ending stocks of ferrous scrap, December 31	450	421	416	415 r	197
Total, all manufacturing types:					
Ferrous scrap consumption	65,600	63,900	64,200	67,400 r	53,100
Pig iron consumption	38,100	37,600	37,400	34,400	30,200
Direct-reduced iron consumption	1,750	1,540	2,050	1,960	1,360
Net receipts of ferrous scrap[3]	50,800	51,700	52,500	56,200 r	43,400
Home scrap production[4]	15,000	12,100	11,900	11,800 r	9,560
Ending stocks, December 31:					
Ferrous scrap at consumer plants	4,970	4,370	4,420	4,620 r	3,410
Pig iron at consumer and supplier plants	664	700	771	885 r	507
Direct-reduced iron at consumer plants	263	319	364	435	234
Exports:[6]					
Ferrous scrap (includes tinplate and terneplate):[7]					
Quantity	13,000	14,900	16,500	21,500	22,400
Value	3,430,000	4,230,000	6,890,000	10,400,000	7,120,000
Pig iron, all grades:					
Quantity	51	813	71	51	11
Value	8,110	8,750	4,610	11,400	4,200
Direct-reduced iron, steelmaking grade:					
Quantity	(8)	(8)	(8)	1	(8)
Value	16	11	23	97	38
Imports for consumption:[6]					
Ferrous scrap (includes tinplate and terneplate):[7]					
Quantity	3,840	4,820	3,700	3,600	2,990
Value	909,000	1,250,000	1,040,000	1,450,000	814,000
Pig iron, all grades:					
Quantity	6,030	6,730	5,220	4,980	2,420
Value	1,580,000	1,760,000	1,660,000	2,800,000	877,000
Direct-reduced iron, steelmaking grade:					
Quantity	2,170	2,610	2,330	2,340	1,020
Value	361,000	417,000	519,000	971,000	304,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes manufacturers of raw steel that also produce steel castings.

[3] Net receipts of scrap is defined as receipts from brokers, dealers, and other outside sources plus receipts from other company-owned plants minus shipments.

[4] Home scrap production includes recirculating scrap that results from current operations and obsolete home scrap.

[5] Some consumers in the "Manufacturers of steel castings" category also produce iron castings; some consumers in the "Iron foundries and miscellaneous users" category also produce steel castings.

[6] Data from U.S. Census Bureau and U.S. International Trade Commission. Export valuation is free alongside ship, and import valuation is customs value.

[7] Excludes used rails for rerolling and other uses and ships, boats, and other vessels for scrapping.

[8] Less than ½ unit.

TABLE 2

U.S. CONSUMER RECEIPTS, PRODUCTION, CONSUMPTION, SHIPMENTS, AND STOCKS OF IRON AND STEEL SCRAP IN 2009 BY GRADE[1]

(Thousand metric tons)

Grade	Receipts of scrap: From brokers, dealers, and other outside sources	Receipts of scrap: From other company-owned plants	Production of home scrap: Recirculating scrap from current operations	Production of home scrap: Obsolete scrap[2]	Consumption of purchased and home scrap	Shipments of scrap	Ending stocks, December 31
Manufacturers of pig iron and raw steel and castings:							
Carbon steel:							
Low-phosphorus plate and punchings	686	W	18	--	714	--	125
Cut structural and plate	3,100	145	503	--	3,810	15	190
No. 1 heavy-melting steel	3,720	277	1,650	W	5,530	132	292
No. 2 heavy-melting steel	5,000	67	260	--	5,370	14	307
No. 1 and electric furnace bundles	2,820	179	W	48	3,680	173	243
No. 2 and all other bundles	788	W	W	--	804	W	36
Electric furnace, 1 foot and under (not bundles)	20	--	W	--	66	W	W
Railroad rails	146	23	W	--	210	W	3
Turnings and borings	1,790	203	51	--	2,070	--	93
Slag scrap	863	85	832	W	1,250	513	153
Shredded or fragmentized	8,770	1,250	332	--	10,200	51	625
No. 1 busheling	4,030	80	190	--	4,370	W	167
Steel cans, post consumer	108	2	--	--	108	W	5
All other carbon steel scrap	3,220	196	1,510	W	4,700	259	252
Stainless steel scrap	832	56	366	--	1,260	4	45
Alloy steel (except stainless)	89	W	399	--	517	33	43
Ingot mold and stool scrap	W	--	81	80	62	99	11
Machinery and cupola cast iron	15	W	W	--	18	W	2
Cast-iron borings	112	W	W	--	119	W	8
Motor blocks	--	--	--	--	--	--	--
Other iron scrap	765	83	125	--	943	34	128
Other mixed scrap	1,270	335	176	--	1,800	45	92
Total	38,100	3,070	7,440	135	47,600	1,410	2,820
Manufacturers of steel castings:							
Carbon steel:							
Low-phosphorus plate and punchings	204	W	148	--	371	--	73
Cut structural and plate	51	--	6	--	58	--	2
No. 1 heavy-melting steel	16	--	4	--	22	--	4
No. 2 heavy-melting steel	19	--	--	--	18	--	3
No. 1 and electric furnace bundles	W	--	--	--	W	--	W
No. 2 and all other bundles	--	--	--	--	--	--	--
Electric furnace, 1 foot and under (not bundles)	5	--	3	--	8	--	--
Railroad rails	W	--	W	--	W	--	W
Turnings and borings	26	--	8	W	35	W	--
Slag scrap	W	--	W	--	6	--	--
Shredded or fragmentized	58	--	--	--	57	--	5
No. 1 busheling	74	--	--	--	79	--	3
Steel cans, post consumer	--	--	--	W	--	W	--
All other carbon steel scrap	3	--	32	--	35	W	--
Stainless steel scrap	16	W	20	W	35	--	71
Alloy steel (except stainless)	29	W	32	W	64	--	31
Ingot mold and stool scrap	W	--	W	--	W	W	W
Machinery and cupola cast iron	--	--	--	--	--	--	--
Cast-iron borings	W	--	W	--	W	--	W
Motor blocks	--	--	--	--	--	--	--
Other iron scrap	2	--	--	--	2	--	--
Other mixed scrap	31	--	W	W	45	--	3
Total	586	2	257	14	838	2	397

See footnotes at end of table.

TABLE 2—Continued

U.S. CONSUMER RECEIPTS, PRODUCTION, CONSUMPTION, SHIPMENTS, AND STOCKS OF IRON AND STEEL SCRAP IN 2009, BY GRADE[1]

(Thousand metric tons)

Grade	Receipts of scrap: From brokers, dealers, and other outside sources	Receipts of scrap: From other company-owned plants	Production of home scrap: Recirculating scrap from current operations	Production of home scrap: Obsolete scrap[2]	Consumption of purchased and home scrap	Shipments of scrap	Ending stocks, December 31
Iron foundries and miscellaneous users:							
Carbon steel:							
Low-phosphorus plate and punchings	577	1	141	W	720	--	5
Cut structural and plate	536	12	44	W	545	--	96
No. 1 heavy-melting steel	64	W	W	--	100	--	4
No. 2 heavy-melting steel	93	--	W	--	102	--	3
No. 1 and electric furnace bundles	47	--	--	--	46	--	1
No. 2 and all other bundles	W	--	W	--	W	W	--
Electric furnace, 1 foot and under (not bundles)	91	--	--	--	91	--	1
Railroad rails	27	W	W	--	25	W	4
Turnings and borings	46	--	--	--	46	W	1
Slag scrap	W	W	W	--	W	W	W
Shredded or fragmentized	540	--	W	--	548	--	14
No. 1 busheling	287	W	7	2	295	W	8
Steel cans, post consumer	4	--	W	--	4	--	W
All other carbon steel scrap	33	--	56	W	88	1	2
Stainless steel scrap	2	--	--	W	2	--	--
Alloy steel (except stainless)	2	--	1	--	3	W	--
Ingot mold and stool scrap	25	W	W	--	30	W	10
Machinery and cupola cast iron	288	W	125	W	413	10	26
Cast-iron borings	27	19	9	--	54	1	1
Motor blocks	116	W	482	--	601	W	4
Other iron scrap	92	20	728	3	839	6	13
Other mixed scrap	30	W	53	W	84	5	3
Total	2,930	68	1,700	24	4,640	30	197
Grand total, all manufacturing types:							
Carbon steel:							
Low-phosphorus plate and punchings	1,470	8	307	--	1,800	1	203
Cut structural and plate	3,690	157	553	W	4,410	15	288
No. 1 heavy-melting steel	3,800	278	1,690	W	5,650	132	300
No. 2 heavy-melting steel	5,110	67	261	W	5,490	14	313
No. 1 and electric furnace bundles	2,870	179	W	48	3,730	173	244
No. 2 and all other bundles	791	W	10	--	806	W	36
Electric furnace, 1 foot and under (not bundles)	116	--	75	--	165	W	1
Railroad rails	174	23	W	--	234	5	7
Turnings and borings	1,870	203	59	--	2,150	--	94
Slag scrap	867	85	837	W	1,260	513	154
Shredded or fragmentized	9,370	1,250	339	--	10,800	51	643
No. 1 busheling	4,400	80	197	2	4,740	2	178
Steel cans, post consumer	112	2	W	W	112	W	5
All other carbon steel scrap	3,260	196	1,600	3	4,820	259	255
Stainless steel scrap	850	56	386	--	1,300	4	116
Alloy steel (except stainless)	120	65	432	W	584	33	75
Ingot mold and stool scrap	71	W	84	80	93	100	222
Machinery and cupola cast iron	303	4	126	W	431	11	28
Cast-iron borings	139	20	10	--	172	1	9
Motor blocks	116	W	482	W	601	W	4
Other iron scrap	858	103	853	3	1,780	41	142
Other mixed scrap	1,330	342	230	14	1,930	51	98
Total	41,600	3,140	9,400	173	53,100	1,440	3,410

W Withheld to avoid disclosing company proprietary data; included in "Total." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Obsolete home scrap includes ingot molds, stools, and scrap from old equipment and buildings.

TABLE 3
U.S. CONSUMER RECEIPTS, PRODUCTION, CONSUMPTION, SHIPMENTS, AND STOCKS OF PIG IRON AND DIRECT-REDUCED IRON IN 2009[1]

(Thousand metric tons)

	Receipts	Production	Consumption	Shipments	Stocks, December 31
Manufacturers of pig iron, raw steel, and castings:					
Pig iron	7,260 [2]	21,400	28,300	76	480
Direct-reduced iron (DRI)	1,110 [3]	W	1,340	W	232
Manufacturers of steel castings:					
Pig iron	9	(4)	17	(4)	(4)
DRI	13	--	14	--	2
Iron foundries and miscellaneous users:					
Pig iron	1,850	11	1,850	24	27
DRI	3	--	3	--	(4)
Total, all manufacturing types:					
Pig iron	9,120	21,400	30,200	100	507
DRI	1,130	W	1,360	W	234

W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes 1.33 million metric tons (Mt) purchased by electric furnace steel producers.

[3] Includes 1.33 million Mt purchased by integrated steel producers.

[4] Less than ½ unit.

TABLE 4
U.S. CONSUMPTION OF IRON AND STEEL SCRAP, PIG IRON, AND DIRECT-REDUCED IRON IN 2009, BY TYPE OF FURNACE OR OTHER USE[1]

(Thousand metric tons)

	Manufacturers of pig iron and raw steel and castings			Manufacturers of steel castings			Iron foundries and miscellaneous users			Total, all manufacturing types		
	Scrap	Pig iron	DRI[2]	Scrap	Pig iron	DRI[2]	Scrap	Pig iron	DRI[2]	Scrap	Pig iron	DRI[2]
Blast furnace	1,270	--	192	--	--	--	--	--	--	1,270	--	192
Basic oxygen process	7,110	25,900	341	--	--	--	--	--	--	7,110	25,900	341
Electric furnace	39,200	2,430	809	837	17	14	3,130	1,700	1	43,200	4,140	824
Cupola furnace	3	--	--	--	--	--	1,510	148	3	1,510	148	3
Other[3]	2	--	--	1	--	--	2	--	--	5	--	--
Direct castings[4]	--	36	--	--	--	--	--	--	--	--	36	--
Total	47,600	28,300	1,340	838	17	14	4,640	1,850	4	53,100	30,200	1,360

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Direct-reduced iron.

[3] Includes air furnaces.

[4] Includes ingot molds and stools.

TABLE 5

IRON AND STEEL SCRAP SUPPLY AVAILABLE FOR CONSUMPTION IN 2009, BY REGION AND STATE[1, 2]

(Thousand metric tons)

Region and State	Receipts of scrap: From brokers, dealers, and other outside sources	Receipts of scrap: From other company-owned plants	Production of home scrap: Recirculating scrap resulting from current operations	Production of home scrap: Obsolete scrap[3]	Shipments of scrap[4]	New supply available for consumption
New England and Middle Atlantic:						
Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	19	(5)	13	W	(5)	32
New Jersey and New York	1,770	--	98	W	W	1,830
Pennsylvania	3,020	820	1,800	63	51	5,640
Total	4,800	820	1,910	63	87	7,510
North Central:						
Illinois	1,340	32	107	10	5	1,490
Indiana	3,660	179	1,720	(5)	354	5,200
Iowa, Nebraska, South Dakota	1,700	16	119	2	W	1,840
Kansas and Missouri	12	5	19	--	(5)	36
Michigan	1,400	(5)	754	--	471	1,680
Minnesota	367	142	17	--	22	504
Ohio	5,160	210	948	21	217	6,120
Wisconsin	1,340	2	909	(5)	5	2,250
Total	15,000	589	4,590	34	1,070	19,100
South Atlantic:						
Delaware and Maryland	962	W	385	--	W	1,300
Florida and Georgia	567	--	6	--	W	573
North Carolina and South Carolina	2,500	W	244	--	--	2,920
Virginia and West Virginia	1,610	W	361	W	13	2,250
Total	5,640	482	996	W	74	7,040
South Central:						
Alabama and Mississippi	3,330	W	189	W	W	3,520
Arkansas, Louisiana, Oklahoma	3,670	W	369	W	W	4,170
Kentucky and Tennessee	2,950	206	248	--	W	3,400
Texas	2,850	545	358	4	20	3,740
Total	12,800	912	1,160	14	54	14,800
Mountain and Pacific:						
Arizona, Colorado, Idaho, Utah	1,300	W	354	W	33	1,710
California, Oregon, Washington	2,160	W	380	W	120	2,730
Total	3,460	338	734	61	153	4,440
Grand total	41,600	3,140	9,400	173	1,440	52,900

W Withheld to avoid disclosing company proprietary data; included in "Total" or "Grand total." -- Zero.

[1] Supply available for consumption is a net figure computed by adding production to receipts and deducting scrap shipped during the year. The difference in stock levels at the beginning and end of the year is not taken into consideration.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Obsolete scrap includes ingot molds, stools, and scrap from old equipment, buildings, etc.

[4] Includes scrap shipped, transferred, or otherwise disposed of during the year.

[5] Less than ½ unit.

TABLE 6
U.S. CONSUMPTION OF IRON AND STEEL SCRAP AND PIG IRON IN 2009, BY REGION AND STATE[1, 2, 3]

(Thousand metric tons)

Region and State	Manufacturers of pig iron and raw steel and castings		Manufacturers of steel castings		Iron foundries and miscellaneous users		Total, all manufacturing types	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
New England and Middle Atlantic:								
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont	1,730	22	9	--	124	4	1,870	25
Pennsylvania	5,350	3,210	136	1	184	17	5,670	3,230
Total	7,090	3,230	145	1	308	21	7,540	3,260
North Central:								
Illinois	1,260	710	24	1	200	20	1,480	731
Indiana	4,910	11,700	36	(4)	235	47	5,180	11,700
Iowa, Kansas, Minnesota, Missouri, Nebraska, South Dakota, Wisconsin	2,540	78	73	(4)	2,020	1,630	4,640	1,710
Michigan	1,260	1,960	28	--	391	32	1,680	1,990
Ohio	5,330	3,330	66	(4)	595	35	5,990	3,360
Total	15,300	17,700	227	1	3,440	1,760	19,000	19,500
South Atlantic:								
Delaware, Maryland, Virginia, West Virginia	3,300	1,580	(4)	(4)	273	9	3,570	1,590
Florida, Georgia, North Carolina, South Carolina	3,180	71	238	--	107	2	3,520	71
Total	6,480	1,650	239	(4)	380	11	7,090	1,660
South Central:								
Alabama, Kentucky, Mississippi, Tennessee	6,510	3,730	129	8	198	20	6,840	3,760
Arkansas, Louisiana, Oklahoma	4,440	483	11	--	5	2	4,450	486
Texas	3,570	37	29	7	135	19	3,740	62
Total	14,500	4,250	169	15	338	41	15,000	4,310
Mountain and Pacific:								
Arizona, Colorado, Idaho, Utah	1,680	1,400	2	(4)	51	(4)	1,740	1,400
California, Oregon, Washington	2,550	49	56	(4)	124	9	2,730	59
Total	4,230	1,450	58	(4)	175	10	4,460	1,460
Grand total	47,600	28,300	838	17	4,640	1,850	53,100	30,200

-- Zero.

[1] Includes recirculating scrap resulting from current operations and home-generated obsolete scrap.

[2] Includes molten pig iron used for ingot molds and direct castings.

[3] Data are rounded to no more than three significant digits; may not add to totals shown.

[4] Less than ½ unit.

TABLE 7

U.S. CONSUMER STOCKS OF IRON AND STEEL SCRAP AND PIG IRON, DECEMBER 31, 2009, BY REGION AND STATE[1]

(Thousand metric tons)

Region and State	Carbon steel[2]	Stainless steel	Alloy steel[3]	Cast iron[4]	Other grades of scrap	Total scrap	Pig iron
New England and Middle Atlantic:							
Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	1	W	--	1	W	1	(5)
New Jersey and New York	51	W	1	1	W	54	1
Pennsylvania	217	12	14	11	3	259	3
Total	269	13	15	13	4	314	4
North Central:							
Illinois	75	(5)	(6)	2	3	80	6
Indiana	390	3	1	12	(6)	413	159
Iowa, Kansas, Missouri, Nebraska, South Dakota	72	(6)	(6)	4	--	75	3
Michigan	91	(6)	(6)	4	(6)	96	1
Minnesota and Wisconsin	52	2	--	3	(6)	57	6
Ohio	389	27	24	54	2	496	47
Total	1,070	36	26	79	13	1,220	222
South Atlantic:							
Delaware, Maryland, Virginia, West Virginia	113	W	(5)	W	W	197	54
Florida, Georgia, North Carolina, South Carolina	243	W	W	W	W	545	10
Total	356	48	29	294	16	742	64
South Central:							
Alabama, Kentucky, Mississippi, Tennessee	435	W	W	4	W	475	134
Arkansas, Louisiana, Oklahoma	207	W	W	W	--	211	66
Texas	161	W	W	W	W	168	2
Total	803	23	3	10	13	854	202
Mountain and Pacific:							
Arizona, Colorado, Idaho, Utah	28	(5)	(5)	(5)	W	69	W
California, Oregon, Washington	196	(5)	2	9	W	218	W
Total	224	(5)	2	9	52	287	15
Grand total	2,720	116	75	405	98	3,410	507

W Withheld to avoid disclosing company proprietary data; included in "Total" or "Grand total." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes rerolling rails.

[3] Excludes stainless steel.

[4] Includes borings.

[5] Less than ½ unit.

[6] Withheld to avoid disclosing company proprietary data; included in "North Central Total" of "Total Scrap."

TABLE 8
U.S. AVERAGE MONTHLY PRICE AND COMPOSITE PRICE FOR NO. 1 HEAVY-MELTING STEEL, WITH ANNUAL AVERAGES[1]

(Dollars per metric ton)

Period	Chicago, IL	Philadelphia, PA	Pittsburgh, PA	Composite price
2008, average	349.48	336.05	357.71	348.86
2009:				
January	183.00	210.00	209.50	200.83
February	176.68	200.53	188.16	188.46
March	157.73	176.14	153.64	162.50
April	150.00	158.33	131.90	146.74
May	179.25	184.25	172.50	178.67
June	185.00	189.09	180.00	184.70
July	230.00	217.27	216.82	221.36
August	244.29	243.24	233.57	240.37
September	257.86	256.43	256.90	257.06
October	244.76	241.90	244.14	243.60
November	216.32	213.89	213.37	214.53
December	251.05	249.32	256.05	252.14
Average	206.33	211.70	204.71	207.58

[1] Calculated by the U.S. Geological Survey from prices published in American Metal Market.

TABLE 9
U.S. EXPORTS OF IRON AND STEEL SCRAP, BY COUNTRY[1, 2]

(Thousand metric tons and thousand dollars)

Country	2008 Quantity	2008 Value	2009 Quantity	2009 Value
Argentina	1	519	1	369
Australia	1	3,130	(3)	1,520
Austria	2	2,020	(3)	1,480
Bahamas, The	7	1,580	(3)	119
Bangladesh	112	44,000	91	25,100
Belgium	6	11,800	6	5,690
Brazil	2	1,440	64	19,000
Canada	1,670	648,000	971	235,000
Chile	(3)	159	1	393
China	2,810	1,840,000	6,210	2,500,000
Colombia	59	25,300	(3)	233
Dominican Republic	3	968	2	642
Egypt	870	400,000	361	90,500
Finland	57	111,000	30	41,600
France	4	9,700	1	1,490
Germany	7	5,080	12	2,530
Greece	276	117,000	224	53,900
Hong Kong	167	96,100	100	65,800
India	883	365,000	1,580	419,000
Indonesia	371	179,000	369	101,000
Italy	82	44,000	48	17,300
Japan	435	324,000	69	104,000
Korea, Republic of	2,620	1,200,000	3,110	939,000
Malaysia	1,260	512,000	689	189,000
Mexico	847	341,000	668	159,000
Netherlands	21	42,600	5	5,610
Netherlands Antilles	2	1,060	1	127
New Caledonia	1	5,330	(3)	2,980
Pakistan	190	64,800	333	83,900

See footnotes at end of table.

TABLE 9—Continued
U.S. EXPORTS OF IRON AND STEEL SCRAP, BY COUNTRY[1, 2]

(Thousand metric tons and thousand dollars)

Country	2008		2009	
	Quantity	Value	Quantity	Value
Peru	140	63,500	155	42,400
Portugal	1[r]	216	25	4,460
Saudi Arabia	1[r]	479	1	538
Singapore	47	13,200	38	9,970
Spain	107	77,400	41	29,100
Sweden	1[r]	2,210	13	6,160
Switzerland	94[r]	28,400	55	15,700
Taiwan	2,480	1,170,000	2,230	722,000
Thailand	1,060	451,000	459	120,000
Trinidad and Tobago	8	1,890	12	4,640
Turkey	4,480	2,010,000	3,680	894,000
United Arab Emirates	1	938	1	493
United Kingdom	7	15,600	4	6,260
Vietnam	310	111,000	750	193,000
Other	50[r]	28,700[r]	9	4,380
Total	21,500	10,400,000	22,400	7,120,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes used rails for rerolling and other uses and ships, boats, and other vessels for scrapping. Export valuation is free alongside ship. The United States exported scrap to 94 countries (revised) in 2008 and 92 countries in 2009.

[3] Less than ½ unit.

Sources: U.S. Census Bureau and U.S. International Trade Commission.

TABLE 10
U.S. EXPORTS OF IRON AND STEEL SCRAP, BY CUSTOMS DISTRICT[1, 2]

(Thousand metric tons and thousand dollars)

Customs district	2008		2009	
	Quantity	Value	Quantity	Value
Baltimore, MD	116	56,500	494	158,000
Boston, MA	1,560	690,000	1,270	324,000
Buffalo, NY	282	161,000	168	45,200
Charleston, SC	166	86,400	167	79,800
Charlotte, NC	55	32,000	51	26,200
Chicago, IL	39	15,900	22	6,230
Cleveland, OH	1	1,060	2	702
Columbia-Snake, OR	937	454,000	1,220	346,000
Detroit, MI	502	199,000	210	71,800
Duluth, MN	59	19,300	55	14,500
El Paso, TX	5	664	14	3,110
Great Falls, MT	22	6,490	9	1,990
Honolulu, HI	170	67,100	140	38,800
Houston-Galveston, TX	500	246,000	914	278,000
Laredo, TX	306	87,400	418	99,200
Los Angeles, CA	5,860	3,030,000	4,330	1,730,000
Miami, FL	246	167,000	404	129,000
Mobile, AL	75	39,300	112	49,000
New Orleans, LA	955	473,000	2,230	549,000
New York, NY	3,230	1,700,000	3,110	1,040,000
Nogales, AZ	9	3,960	15	4,340
Norfolk, VA	372	161,000	439	176,000

See footnotes at end of table.

TABLE 10—Continued
U.S. EXPORTS OF IRON AND STEEL SCRAP, BY CUSTOMS DISTRICT[1, 2]

(Thousand metric tons and thousand dollars)

Customs district	2008		2009	
	Quantity	Value	Quantity	Value
Ogdensburg, NY	82	37,900	100	19,900
Pembina, ND	529	205,000	295	83,100
Philadelphia, PA	993	437,000	1,400	356,000
Portland, ME	115	63,700	129	35,600
Providence, RI	442	206,000	374	90,900
San Diego, CA	19	6,200	17	3,360
San Francisco, CA	1,440	618,000	1,760	542,000
San Juan, PR	177	49,700	294	69,500
Savannah, GA	370	224,000	507	237,000
Seattle, WA	1,180	541,000	1,020	317,000
St. Albans, VT	94	36,400	35	8,750
Tampa, FL	519	220,000	583	168,000
Other	101	20,300	116	15,900
Total	21,500	10,400,000	22,400	7,120,000

[1] Excludes used rails for rerolling and other uses and ships, boats, and other vessels for scrapping. Export valuation is free alongside ship.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

Sources: U.S. Census Bureau and U.S. International Trade Commission.

TABLE 11
U.S. EXPORTS OF IRON AND STEEL SCRAP, BY GRADE[1, 2]

(Thousand metric tons and thousand dollars)

Grade	2008		2009	
	Quantity	Value	Quantity	Value
No. 1 heavy-melting scrap	5,240	2,360,000	5,840	1,520,000
No. 2 heavy-melting scrap	382	113,000	903	230,000
No. 1 bundles	248	62,800	311	79,300
No. 2 bundles	23	6,400	55	14,600
Shredded steel scrap	8,410	3,330,000	8,500	2,190,000
Borings, shovelings, and turnings	152	17,700	106	19,800
Cut plate and structural	859	332,000	1,320	359,000
Tinned iron or steel	140	64,300	112	54,000
Remelting scrap ingots	77	101,000	27	35,000
Stainless steel scrap	1,000	1,190,000	1,130	777,000
Other alloy steel scrap	1,680	1,330,000	1,280	900,000
Other steel scrap[3]	2,740	1,200,000	2,170	718,000
Iron scrap	589	262,000	668	223,000
Total	21,500	10,400,000	22,400	7,120,000
Ships, boats, and other vessels for scrapping	4	354	4	773
Used rails for rerolling and other uses[4]	76	54,900	59	38,700
Grand total	21,600	10,400,000	22,500	7,160,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Export valuation is free alongside ship.

[3] Includes tinplate and terneplate.

[4] Includes mixed (used plus new) rails. More information can be found in table 15.

Source: U.S. Census Bureau.

TABLE 12

U.S. IMPORTS FOR CONSUMPTION OF IRON AND STEEL SCRAP, BY COUNTRY[1, 2]

(Thousand metric tons and thousand dollars)

Country	2008		2009	
	Quantity	Value	Quantity	Value
Argentina	1	2,270	4	737
Bahamas, The	4	1,240	3	599
Belgium	(3)	61	--	--
Brazil	3	1,930	3	2,670
Canada	2,790	1,020,000	2,400	611,000
China	1	405	(3)	281
Colombia	(3)	1,220	(3)	1,120
Denmark	15	11,300	26	6,290
Dominican Republic	(3)	411	(3)	222
Egypt	(3)	502	1	637
Finland	17	4,780	--	--
Germany	5	5,430	54	14,400
Guadeloupe	9	2,150	3	182
Guatemala	1	1,340	(3)	255
Japan	28	2,870	2	695
Malaysia	(3)	258	(3)	103
Mexico	333	151,000	207	83,900
Netherlands	61	36,800	76	21,100
Netherlands Antilles	6	2,400	1	89
Spain	1	1,890	(3)	281
Sweden	88	44,100	100	27,300
Taiwan	(3)	225	1	2,690
Trinidad and Tobago	1	1,630	(3)	164
United Kingdom	223	153,000	101	33,500
Other	6 r	6,580 r	9	5,150
Total	3,600	1,450,000	2,990	814,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes used rails for rerolling and other uses and ships, boats, and other vessels for scrapping. Import valuation is customs value. The United States imported scrap from 59 countries (revised) in 2008 and 46 countries in 2009.

[3] Less than ½ unit.

Sources: U.S. Census Bureau and U.S. International Trade Commission.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF IRON AND STEEL SCRAP, BY CUSTOMS DISTRICT[1, 2]

(Thousand metric tons and thousand dollars)

Customs district	2008		2009	
	Quantity	Value	Quantity	Value
Baltimore, MD	3	7,150	2	1,240
Buffalo, NY	496	258,000	596	185,000
Charleston, SC	284	154,000	178	44,300
Charlotte, NC	1	847	(3)	46
Chicago, IL	35	3,990	15	1,290
Cleveland, OH	(3)	292	(3)	427
Columbia-Snake, OR	97	29,000	36	6,570
Detroit, MI	1,060	391,000	644	157,000
Duluth, MN	69	23,500	52	13,700
El Paso, TX	53	26,600	35	10,200
Great Falls, MT	59	23,200	93	19,700
Houston-Galveston, TX	30	36,000	3	7,680
Laredo, TX	85	48,300	84	46,700
Los Angeles, CA	24	5,820	2	3,430
Miami, FL	(3)	546	5	1,210
Mobile, AL	47	21,900	65	21,200
New Orleans, LA	141	99,300	138	41,300
New York, NY	4	1,390	(3)	641
Nogales, AZ	8	3,070	11	3,730
Norfolk, VA	(3)	10	(3)	109
Ogdensburg, NY	19	22,500	38	15,600
Pembina, ND	72	35,700	25	11,400
Portland, ME	4	3,160	7	2,570
San Diego, CA	177	49,400	79	21,900
Seattle, WA	820	201,000	878	195,000
Tampa, FL	3	2,080	3	552
Other	4	705	3	986
Total	3,600	1,450,000	2,990	814,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes used rails for rerolling and other uses and ships, boats, and other vessels for scrapping. Import valuation is customs value.

[3] Less than ½ unit.

Sources: U.S. Census Bureau and U.S. International Trade Commission.

TABLE 14

U.S. IMPORTS FOR CONSUMPTION OF IRON AND STEEL SCRAP, BY CLASS[1, 2]

(Thousand metric tons and thousand dollars)

Class	2008		2009	
	Quantity	Value	Quantity	Value
No. 1 heavy-melting scrap	166	56,300	185	37,900
No. 2 heavy-melting scrap	36	11,600	28	5,510
No. 1 bundles	865	458,000	715	186,000
No. 2 bundles	36	8,150	37	5,430
Shredded steel scrap	444	129,000	452	78,500
Borings, shovelings, and turnings	76	19,300	53	10,100
Cut plate and structural	162	42,600	149	29,600
Tinned iron or steel	26	7,040	27	5,190
Remelting scrap ingots	(3) r	9	(3)	327
Stainless steel scrap	140	217,000	124	138,000
Other alloy steel scrap	629	186,000	558	193,000
Other steel scrap[4]	666	219,000	479	90,300
Iron scrap	349	95,100	184	34,400
Total	3,600	1,450,000	2,990	814,000
Ships, boats, and other vessels for scrapping	(3) r	18	(3)	79
Used rails for rerolling and other uses[5]	151	80,600	57	17,700
Grand total	3,750	1,530,000	3,050	831,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Import valuation is customs value.

[3] Less than ½ unit.

[4] Includes tinplate and terneplate.

[5] Includes mixed (used plus new) rails. More information can be found in table 16.

Source: U.S. Census Bureau.

TABLE 15

U.S. EXPORTS OF USED RAILS FOR REROLLING AND OTHER USES, BY COUNTRY[1, 2]

Country	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)
Anguilla	53	$106	121	$127
Antigua and Barbuda	5	11	23	51
Argentina	80	205	5	13
Aruba	15	15	34	33
Australia	1,370	2,590	534	759
Bahamas, The	173	216	57	89
Barbados	336	349	88	74
Brazil	11	45	26	34
British Virgin Islands	1	6	70	109
Canada	32,900	19,000	17,000	15,100
Cayman Islands	173	317	53	58
Chile	51	139	781	956
China	52	30	4,970	1,570
Colombia	226	283	342	588
Costa Rica	--	--	4	4
Dominican Republic	803	1,120	561	633
France	(3)	4	--	--
Germany	441	1,110	--	--
Guatemala	321	267	--	--
Honduras	86	82	27	46
Hungary	52	370	--	--
India	326	231	10	9
Ireland	59	50	128	114
Israel	27	112	--	--
Italy	86	186	3	11
Jamaica	2,900	2,820	--	--
Japan	--	--	37	36
Korea, Republic of	13	11	4	3
Malaysia	--	--	13	11
Mexico	28,100	17,900	29,300	15,700
Netherland Antilles	328	318	36	36
New Zealand	--	--	11	20
Nicaragua	20	53	15	27
Pakistan	16	18	45	9
Panama	28	57	33	48
Peru	124	139	65	147
Philippines	4	12	--	--
Singapore	8	31	--	--
South Africa	486	504	87	80
Spain	--	--	3	3
Taiwan	2,830	1,320	2,920	1,210
Thailand	74	62	124	83
Trinidad and Tobago	561	2,700	25	35
Turkey	8	15	7	10
Turks and Caicos Islands	28	72	10	17
United Arab Emirates	37	93	446	373
United Kingdom	216	408	25	32
Venezuela	187	265	88	184
Vietnam	1,940	878	--	--
Other	314 r	329 r	374	356
Total	75,800	54,900	58,600	38,700

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Export valuation is free alongside ship.

[3] Less than ½ unit.

Sources: U.S. Census Bureau and U.S. International Trade Commission.

TABLE 16
U.S. IMPORTS FOR CONSUMPTION OF USED RAILS FOR REROLLING AND OTHER USES, BY COUNTRY[1,2]

	2008		2009	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Austria	7	$14	--	--
Canada	95,800	45,300	31,300	$7,950
Czech Republic	4	9	7	9
Germany	6	11	2	7
Japan	9	17	17	40
Mexico	196	267	830	238
Russia	53,500	33,700	25,200	9,310
Spain	--	--	13	116
Switzerland	1	3	--	--
Taiwan	9	27	--	--
United Kingdom	1,780	1,320	--	--
Total	151,000	80,600	57,400	17,700

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Import valuation is customs value.

Sources: U.S. Census Bureau and U.S. International Trade Commission.

TABLE 18
U.S. IMPORTS FOR CONSUMPTION OF DIRECT-REDUCED IRON, BY COUNTRY[1,2]

	2008		2009	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Brazil	5,000	$1,500	--	--
Trinidad and Tobago	1,380,000	493,000	807,000	$244,000
Venezuela	954,000	477,000	209,000	59,600
Total	2,340,000	971,000	1,020,000	304,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Data are for steelmaking-grade direct-reduced iron only.

Sources: U.S. Census Bureau and U.S. International Trade Commission.

TABLE 19

U.S. EXPORTS OF PIG IRON, BY COUNTRY[1,2]

Country	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)
Bolivia	--	--	1	$4
Brazil	30	$20	11	12
Canada	22,600	8,600	5,220	1,890
China	156	167	361	119
Denmark	1	4	--	--
Dominican Republic	189	201	--	--
Finland	10	5	--	--
France	37	6	62	18
French Polynesia	--	--	82	27
Guatemala	261	15	--	--
Hong Kong	35	37	--	--
India	47	28	--	--
Israel	43	25	--	--
Italy	--	--	11	4
Japan	--	--	59	19
Korea, Republic of	152	163	248	244
Kuwait	81	87	--	--
Mexico	4,630	1,900	4,400	1,640
Netherland	--	--	2	3
New Zealand	--	--	11	4
Peru	--	--	103	34
Romania	--	--	14	15
Singapore	55	55	--	--
Taiwan	15	14	--	--
Tunisia	--	--	147	157
United Kingdom	22,800	38	2	6
Total	51,100	11,400	10,700	4,200

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes the following grades of pig iron: less than or equal to 0.5% phosphorus content, greater than 0.5% phosphorus content, and alloy grade. Export valuation is free alongside ship value.

Sources: U.S. Census Bureau and U.S. International Trade Commission.

TABLE 20

U.S. IMPORTS FOR CONSUMPTION OF PIG IRON, BY COUNTRY[1, 2]

Country	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)
Brazil	3,610,000	$1,990,000	1,260,000	$478,000
Canada	182,000	102,000	90,700	27,300
Denmark	--	--	9	9
India	2	6	6	13
Italy	--	--	4	2
Russia	711,000	413,000	751,000	275,000
Singapore	3	6	--	--
South Africa	92,900	52,300	120,000	37,400
Sweden	33,400	19,400	43,000	12,000
Trinidad and Tobago	12,000	5,990	--	--
Ukraine	310,000	207,000	156,000	47,000
United Kingdom	35	61	--	--
Venezuela	29,200	8,460	--	--
Total	4,980,000	2,800,000	2,420,000	877,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes the following grades of pig iron: less than or equal to 0.5% phosphorus content, greater than 0.5% phosphorus content, and alloy grade. Import valuation is customs value.

Sources: U.S. Census Bureau and U.S. International Trade Commission.

IRON ORE

By John D. Jorgenson

Domestic survey data and tables were prepared by Michelle B. Blackwell, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

U.S. iron ore production in 2009 was one-half that of 2008; consumption during this same period decreased by 40%. World iron ore production and consumption once again rose in 2009, but by only 2%. China, by far the leading consumer, led gross tonnage production of iron ore with relatively low-grade ore. China was the leading producer of iron ore in terms of iron content, followed by Australia and Brazil (tables 1, 17). For the eighth consecutive year, world iron ore trade increased. World prices dropped significantly compared with those of 2008.

Iron ore is the basic raw material for producing iron and steel. The supply of iron ore is critical to the economies of all industrialized nations. Scrap, a supplement to iron ore in steelmaking, is also an extremely important feed material, but owing to lack of supply of high-quality scrap, its use has limitations. Direct reduced iron (DRI) is an alternative to scrap, but requires iron ore for its production.

Two iron oxides—hematite (Fe_2O_3) and magnetite (Fe_3O_4)—are the primary ore minerals of iron. Taconite, the primary iron ore mined in the United States, contains hematite and magnetite in varying proportions and is found in hard, fine-grained, banded iron formations with low iron content, between 20% and 30%. Almost all domestic iron ore production is transformed into molten iron in blast furnaces by the iron and steel industry. Most molten iron then goes directly to a basic oxygen furnace (BOF) for conversion to steel by removing most of the residual carbon. The remainder is poured into molds to produce pig iron.

In 2009, the United States used 31.0 million metric tons (Mt) of iron ore, a decrease of 20.9 Mt, or 40%, compared with that of 2008, and produced 19.0 Mt of pig iron. Pig iron production decreased 44% from that of 2008 and was at the lowest level since before World War II.

Raw steel production, at 59.4 Mt, decreased 35% compared with that of 2008. U.S. steel consumption decreased to 63 Mt from 102 Mt in 2008. Imported iron ore supplements domestically produced iron ore in the production of pig iron, which is used along with imported pig iron, DRI, and scrap to produce raw steel. Integrated steel mills produce steel from iron ore; minimills produce steel from DRI and scrap. In 2009, the minimill sector of the steel industry made up 62% of the U.S. raw steel production (American Iron and Steel Institute, 2010, p. 73).

Integrated steelmakers can increase steel mill product production without increasing blast furnace production by importing pig iron and semifinished steel. This permits steelmakers to avoid costly startup of less-efficient blast furnaces held in reserve and the employment of additional skilled workers. In 2009, net U.S. exports (exports minus imports) of iron ore substitutes were 5.7 Mt, while in 2008 the United States was a net exporter of 14.8 Mt of substitutes. This increase in exports was owing to continued high levels of scrap steel net exports combined with substantial decreases in net imports of DRI, pig iron, and semifinished steel products. During the year, along with the 33% decrease in raw steel production and a 38% drop in steel demand, iron ore consumption declined 40% from 2008 levels.

Legislation and Government Programs

In 2009, the Minnesota production tax rate to be distributed in 2010 changed for concentrates and pellets produced in 2009, increasing to $2.364 from $2.316 per taxable long ton. The taxable tonnage for 2009 is based on the average tonnage produced in 2007–09.

Changes affecting taconite mining and processing operations passed by the Minnesota Legislature in 2009 included production taxation items that would be based on the 2008 and 2009 production. A Taconite Environmental Protection Fund was established to receive 15.5 cents per long ton (about 15.3 cents per metric ton) from 2008 production that would have gone into the Taconite Property Tax Relief Account. Instead, these funds were set aside for use in renewable energy initiatives to be distributed in 2009 only. A production tax change for 2009 that would affect distribution of taxes in 2010 and thereafter included redistribution to 50% mining and 50% processing from 40% mining and 60% processing of the proceeds when mining and processing were carried out in two separate tax districts. Another production tax change for 2009 that would affect distribution of taxes in 2010 was a redistribution of excess tax funds to cities and towns within a school district if distribution to the school district would reduce State aid to the district (Minnesota Department of Revenue, 2009, p. 1, 6, 7, 20; 2010, p. 1, 20).

Production

The U.S. Geological Survey (USGS) develops U.S. iron ore production data through an annual "Iron Ore" survey, which is sent to iron ore mines, and those mines provided the production statistics listed in tables 1 through 5. This information is supplemented by employment data, information from consumers, and mine inspection reports. The American Iron Ore Association became a supplier-oriented organization, now known as the Iron Mining Association of Minnesota, and no longer provides data on ore shipments from loading docks on the Upper Great Lakes nor receipts at transfer docks and furnace yards nationwide. Steel plant data continues to be compiled by the American Iron and Steel Institute (AISI).

In 2009, domestic iron ore production was 26.7 Mt, about one-half of the 2008 production, which was 53.6 Mt. Michigan and Minnesota taconite mines accounted for almost all domestic iron ore production—six mines operated on the Mesabi Range in northeastern Minnesota and two on the Marquette Range in Michigan's Upper Peninsula. Domestic iron ore supply (production minus exports) met 74% of domestic demand in 2009, 3% less than the average from 2005 through 2008.

Cliffs Natural Resources Inc. (Cleveland, OH) announced 2009 iron ore production for its North American operations. Mine production, which totaled 20 Mt, was as follows (United States, unless otherwise specified)—Empire, 2.6 Mt; Hibbing Taconite, 1.7 Mt; Northshore, 3.3 Mt; Tilden, 5.7 Mt; United Taconite, 3.9 Mt; and Wabush (Canada), 2.7 Mt. Cliffs' share of the total production from these North American operations was 17.4 Mt. Total Cliffs' North American production tonnage share for the mines it managed during the year decreased by 25% compared with that of 2008, and overall iron ore sales revenue decreased to $1.45 billion, a decrease of 39% compared with that of 2008 (Cliffs Natural Resources Inc., 2010, p. 56, 57).

In June 2009, Cliffs acquired significant ownership of Freewest Resources Canada Inc. (Montreal, Quebec, Canada), with its three world-class chromite deposits in anticipation of diversifying downstream from its core merchant iron ore business. Cliffs planned to include construction of the open pit mine and mine-site processing facility, as well as an electric arc furnace (EAF) to further process the chromite ore into high-grade ferrochromium. The EAF facility was expected to be located on the north shore of Lake Superior after a permitting process anticipated to require approximately 3 years, with production startup in about 2015 (Cliffs Natural Resources Inc., 2009a).

Michigan.—Michigan accounted for about 31% of U.S. usable iron ore output in 2009; nearly all of Michigan's output was pellet production. The Empire Mine production was mostly flux pellets. The Tilden Mine produced magnetite and hematite flux pellets. The Empire Mine and the Tilden Mine production each showed a decrease of 2.0 Mt compared with that of 2008. Owing to a postponement of a development project, the reserve estimate for the Empire Mine was reduced by 45%, while Tilden Mine reserves remained the same net of production (Cliffs Natural Resources Inc., 2010, p. 35, 57; Skillings Mining Review, 2010c, p. 6–7).

Minnesota.—Minnesota produced 69% of the usable iron ore in the United States in 2009; nearly all of the output was pellet production. Almost all of the production from the State came from open pits on the Mesabi Iron Range, although a minor amount of the production did come from reworked tailings. Minnesota pellet production, grouped by operating company, was summarized as follows: Hibbing Taconite Company produced standard and high-compression pellets; Northshore Mining Company produced 3.3 Mt of standard pellets, including a small amount of sinter material and concentrate; United Taconite Company, LLC produced pellets and a minor amount of concentrates; ArcelorMittal Minorca Mine Inc. (Chicago, IL) produced 1.5 Mt of flux pellets, including a minor amount of pellet chips; and United States Steel Corp. (Pittsburgh, PA) had no production from its Keewatin Taconite operations and 7.7 Mt of acid and flux pellet production from its Minntac operations (ArcelorMittal, 2010, p. 51; Cliffs Natural Resources Inc., 2010, p. 57; Skillings Mining Review, 2010b, p. 8, 12–15; United States Steel Corp., 2010, F–62).

In early February, U.S. Steel announced plans to lay off 500 union employees, as well as 90 management employees at its Minntac operations (Mountain Iron, MN). In December [2008], U.S. Steel had already halted production at its Keetac operation (Keewatin, MN). Lack of new steel orders forced the steel company to reduce production from its upstream operations (Bowen, 2009), but by August, with rising steel requirements, the company announced plans to start up an additional pellet production line at the Minntac plant in Iron Mountain, MN, and to start up an additional two lines in September. U.S. Steel would then have four of the five production lines at Minntac in operation (Skillings Mining Review, 2009d), but at Keetac, the company had workers begin winterizing the plant in anticipation of extending the shutdown of operations (Skillings Mining Review, 2009b).

ArcelorMittal (Luxembourg) attributed the reduction in production from 2.8 Mt in 2008, to a shutdown of operations between May and September in 2009. Owing to market conditions, no iron ore was produced during this period (ArcelorMittal, 2010, p. 51).

Cliffs extended the shutdown of the Northshore Mining Co. facilities, which had been initiated in April through July (Skillings Mining Review, 2009e). Cliffs indicated that the joint-venture owners of the Hibbing Taconite Mine [ArcelorMittal, 62.3%; Cliffs, 23.0%; and U.S. Steel Canada Inc. (Hamilton, Ontario, Canada), 14.7%] had agreed to lengthen the shutdown at the plant, which has a rated capacity of 8.1 million metric tons per year (Mt/yr). This extended the shutdown—which started with two of three pellet lines shut down in March and then the plant shut down for 15 weeks beginning in May—through the first quarter of 2010 (Cliffs Natural Resources Inc., 2009b).

Steel Dynamics, Inc. (Fort Wayne, IN) completed construction and began commissioning on the $260 million Mesabi Nugget project in Hoyt Lakes, MN. The main plant facility has a 180-foot-diameter gas-fired rotary-hearth furnace (RHF) that, through a chemical reduction process, was expected to yield millions of 96% to 98% iron nuggets. The feed material—iron ore concentrate, coal, and binding agents—was to be mixed and dried to form marblesized "dry balls" in ancillary facilities. These balls were then to be melted in the RHF to form the iron nuggets. At full capacity, the plant was expected to produce 500,000 metric tons per year (t/yr) of iron nuggets. Steel Dynamics expected to follow through with additional investments in an adjacent iron mine, once the required permits were received from the State of Minnesota (Skillings Mining Review, 2009c; Steel Dynamics, Inc., 2010, p. 5).

Magnetation, Inc. (Nashwauk, MN) began production of iron concentrate from its Mesabi Chief plant near Keewatin, MN. Magnetation invested $9.6 million to bring its plant online. The plant was expected to produce low-cost iron concentrates at a rate of 300,000 t/yr from lean ore stockpiles of hematite and natural ore tailings. Plans for expansion to 750,000 t/yr of concentrate were being made to help feed the 500,000 t/yr (96% to 98% iron) Mesabi Nugget facility being constructed at nearby Hoyt Lakes, MN, by Steel Dynamics (Metal Bulletin, 2009e; Redmon, 2009).

Consumption

U.S. iron ore consumption declined by 40% to 31.0 Mt from the 2008 figure of 51.9 Mt (table 1). Pig iron production, at 19.0 Mt in 2009, was almost one-half of the 5-year average of 37.5 Mt/yr for 2004 through 2008. Raw steel production using BOF technology, which had been at the lowest production level in more than a decade in 2008, decreased by more than 40% to 22.7 Mt.

Consumption of iron ore, including agglomerates, reported to the AISI by producers of iron and steel totaled 30.3 Mt, including 26.2 Mt of pellets; 3.8 Mt of sinter, briquettes, and other products; and 0.3 Mt of natural coarse ore (table 7). Of the ore consumed, 74% was domestic production; 10%, imports from Canada; 2%, imports from other countries; and the balance was drawdowns of domestic stocks. Other iron-bearing materials charged to blast furnaces included mill scale, slag scrap, and steel furnace slag.

The three consumption numbers used in this annual review are reported in tables 1, 7, and 8. The first consumption number (31.0 Mt in 2009), in table 1, is the sum of the ore consumed by input type reported by the AISI, the ore consumed in DRI production, and the ore consumed in nonsteel uses, as reported to the USGS (American Iron and Steel Institute, 2010, p. 81). The second consumption number (30.4 Mt in 2009), in table 7, is the ore consumed in U.S. iron and steel plants by type of ore reported by the AISI. The third consumption number is an estimate of DRI and other miscellaneous uses, which include iron ore consumed in production of cement and iron ore shipped for use in manufacturing paint, ferrites, heavy media, cattle feed, refractory and weighing materials, and for use in lead smelting are listed in table 8. The latter consumption figure was the ore consumed in DRI production (of which there was none produced in 2009) and nonsteel uses (0.60 Mt in 2009). Data on iron ore consumption in nonsteel end uses (table 8) were compiled from USGS surveys and information provided by Midrex Technologies, Inc. (2010, p. 7).

Prices

At the beginning of 2009, the secretary general of the China Iron & Steel Association (CISA) reportedly indicated that China would not seek "unreasonable decreases" during 2009 iron ore contract price negotiations. China tried to negotiate for price reductions to be made retroactive to January so that Chinese mills would not be forced to pay 2008 negotiated prices. CISA indicated that it would like more flexibility to adjust prices midyear, but did not want to be hampered by an iron ore index for long-term supply contracts (Li, 2009). CISA for the first time included a representative in the Chinese delegation discussing annual iron ore price contracts. CISA reportedly wanted to strengthen coordination among Chinese steel producers and would need to agree to any benchmarks established by China's major producers (Metal Bulletin, 2009b).

As the April 1 annual contract date passed, contract negotiations continued between the leading iron ore producers and steelmakers. BHP Billiton Ltd. (Melbourne, Australia) indicated that it would like to eliminate the 12-month contract system using either the spot market or some type of index price. Both Vale S.A. (Rio de Janeiro, Brazil), the world's leading producer of iron ore which had officially changed its corporate name from Companhia Vale do Rio Doce (CVRD), and Rio Tinto plc (London, United Kingdom) favored continuing with a contract price because they felt it was more stable. At the time of the negotiations, China reportedly was expected to reduce iron ore imports in 2009 by 20% compared with 2008 import levels. A price reduction of upwards of 30% was expected to be negotiated for contract year 2009–10 (Matthews, 2009a; Vale S.A., 2009a).

At the end of May, Rio Tinto settled the 2009–10 annual iron ore contract with Japanese steel firms—JFE Holdings Inc., Kobe Steel Ltd., Nippon Steel Corp., and Sumitomo Metal Industries Ltd.—and Korea's POSCO. The agreement was for a 33% lower price for fines and a 44% lower price for lump ore, the first price reduction in 7 years. Chinese steelmakers continued to negotiate deeper discounts on both lump and fine ores. Vale continued discussions with steel firms (Thompson, 2009). Despite the impasse in iron ore price negotiations, Chinese imports of iron ore through May 2009, at 242 Mt, increased 26% compared with those of the same period in 2008. The import value of this ore was almost 28% lower when comparing these two periods (TEX Report, The, 2009c).

Following the rejection of a $19.5 billion investment offer to increase its ownership of Rio Tinto by the Aluminum Corp. of China Ltd. (Chinalco) (Beijing, China) and the subsequent decision to develop a joint venture of Australian iron ore assets by BHP Billiton and Rio Tinto, an Australian executive of Rio Tinto was arrested by Chinese authorities on suspicion of espionage and stealing state secrets (Ritchie, 2009). The failed offer, joint venture, and arrest of Rio Tinto's executive came amidst a failure by BHP Billiton, Rio Tinto, and Vale, to reach an annual contract price agreement with Chinese iron ore purchasers. Vale appeared to be holding back to avoid repeating the 2008 problem of settling earlier for a lower price than either BHP Billiton or Rio Tinto (Matthews, 2009b).

A move to a more market-based, rather than negotiated, contract iron ore price became evident. At the end of the July, BHP Billiton announced that it had reached agreement on 53% of its iron ore sales for the 2009 contract year. Only 23% was set based on the annual contract price, while the other 30% was priced using quarterly, spot, and index-based prices. In 2008, when spot prices collapsed, some buyers reneged on contracts, leaving annual contract prices little more than an upside limit for producers. The arrest of the Rio Tinto executive in China gave additional incentive for producers to rely to a greater degree on independently established market prices (Denning, 2009). Amidst the continued stalemate between Chinese buyers and worldwide iron ore producers, an iron ore trade association—the Iron Ore & Steel Derivatives Association (IODA)—was formed to promote the trade of iron ore and related derivates, develop standard terms for iron ore contract transactions, and support the development and use of independent market indices. IODA was seen, by itself, as having an important role in the iron ore market as the market moved from annual contract pricing toward a spot market (Metal Bulletin, 2009d).

Fortescue Metals Group Ltd. (East Perth, Australia) agreed to a price 3% below the benchmark into the Asian markets for its iron ore sold to Chinese steel mills. This agreement permitted Fortescue to complete a $6 billion deal to obtain financing from Chinese sponsors for project expansion (Mining Journal, 2009b).

As negotiating posturing began for 2010 contract negotiations, CISA indicated that iron ore oversupply would worsen in the fourth quarter of 2009. China's imports for the first three quarters were 469.4 Mt of iron ore, an increase of almost 36% from those of the same period during the previous year. CISA was pressing a unified iron ore import price and a qualifications review for iron ore importers (Metal Bulletin, 2009c).

Transportation

The Lake Carriers' Association reported that the iron ore shipments on the Great Lakes fell to the lowest level in 71 years. Iron ore cargos on the Great Lakes (includes Great Lakes and St. Lawrence Seaway ports to Great Lakes destinations) totaled 28.8 Mt, the lowest level since 1938. Iron ore shipments for 2009 were 53% of the 5-year average of 2004–08. The Soo Locks on the Great Lakes closed for the season on January 15 and were reopened on March 25 in accordance with a multiagency agreement to allow inspection and maintenance of systems, structures, and key equipment (Great Lakes & Seaway Shipping News, 2009; Lake Carriers' Association, 2010a, b).

Early in 2009, the *CSL Argosy*, an 800-foot bulk carrier loaded with iron ore, ran aground in the Chesapeake Bay, just north of Annapolis, MD. The vessel, headed to Baltimore, MD, had 19,300 t of iron ore removed and was refloated before proceeding to inspection in Annapolis (American Metal Market, 2009).

Foreign Trade

In 2009, U.S. exports of iron ore exceeded imports by a slight margin, which represented only a minor percentage of domestic apparent consumption. Exports decreased by 65%, while imports decreased by 58% compared with 2008 figures. U.S. iron ore exports were 96% pellets (3.8 Mt), and 78% of the exports was shipped via the Great Lakes to Canadian steel companies, while 6% was shipped to Germany, 5% each to Belgium and France, 3% to China, 2% to Mexico, and the rest to 21 other countries. U.S. imports totaled 3.9 Mt, of which Brazil's share decreased to 5% from 28% in 2008, Canada's share increased to 81% from 64%, and Chile's share increased to 5% from 2% in 2008 (tables 1, 9–15).

World Industry Structure

Consumption.—Although global iron ore consumption is not measured directly, imports of iron ore and production of crude steel, DRI, and pig iron can be used as guides to indicate whether consumption rises or falls. DRI and pig iron production are likely to be more direct indicators of iron ore consumption than crude steel production because, to varying degrees in each country, part of steel production comes from scrap consumption in minimills. Iron ore net imports cannot be used as a straightforward indicator of a change in iron ore consumption in countries that produce iron ore unless a country's ore production remains constant. World consumption of iron ore was estimated to have decreased slightly as indicated by slight decreases in pig iron and DRI production compared with 2008 levels. Of the nine countries that had 2% or more of world pig iron production in 2009, seven of the countries showed negative growth, including the United States, comparing 2009 production with each country's average pig iron production from 2005 through 2009. The growth rates compared with the 5-year average (2005–09) for these countries were as follows: India, 26%; China, 22%; Republic of Korea, -4%; Russia, -10%; Japan, -18%; Ukraine, -18%; Germany, -28%; Brazil, -42%; and the United States, -43%. Of the five leading producing countries of pig iron in 2009, only China (16%) and India (32%) showed an increase in production from that of 2008—decreases for the other countries were as follows: Japan, 22%; the Republic of Korea, 12%; and Russia, 10%.

Interest in mine development increased toward the end of 2009 owing to a recovery from the global economic downturn, as producers positioned themselves to take advantage of expected continuing high levels of consumption driven by Chinese economic growth. With new iron ore production capacity, world supply of iron ore was expected to be adequate through 2010.

World crude steel production fell to 1.2 billion metric tons (Gt) from 1.3 Gt in 2008. Six countries produced more than 30 Mt of crude steel each and combined accounted for almost 70% of world production in 2009. Of those countries, China produced about 68 Mt more crude steel in 2009 than in 2008 and India produced 8 Mt more. The others (Germany, Japan, Republic of Korea, and the United States) combined produced 83 Mt less crude steel in 2009 than in 2008. Annual world crude steel production, excluding China, decreased by more than 130 Mt in 2009. Between 2000 and 2009, China, Germany, India, Japan, Republic of Korea, Russia, and the United States accounted for two-thirds of combined world crude steel production. China's 2009 production was more than 70% greater than its average for the 10-year period, while that of the United States was 37% less than its average for the 10-year period (United Nations Conference on Trade and Development, 2010, p. 118–121).

Production.—World iron ore production of 2.2 Gt, gross weight, increased slightly from 2008 production levels. Annual world production has exceeded 1 Gt, gross weight, each year since it first reached that level in 1995, and has exceeded 2 Gt since 2007. Australia's and Brazil's combined share of world production by gross weight from 2005 through 2009 averaged 32%. In 2009, iron ore was produced in 42 countries, with production exceeding 1 Mt, gross weight, in 28 of those countries. World DRI production decreased to 64.4 Mt, which was 5% less than that of 2008 (Midrex Technologies, Inc., 2010).

Trade.—World iron ore imports of 941 Mt rose by 4% compared with 2008 levels. Following large year-on-year increases in imports for the past 7 years (21% in 2002, 33% in 2003, 40% in 2004, 32% in 2005, 19% in 2006, 17% in 2007, and 16% in 2008), China posted another sharp rise to 628 Mt in 2009 from 440 Mt in 2008—a gain of more than 40%. Since 2000, four countries have accounted for more than two-thirds of world iron ore imports. Germany's share of imports in that period decreased to 3% from 10%, Japan's share decreased to

11% from 26%, and the Republic of Korea's share decreased to 4% from 8%. China's share more than tripled during this 10-year period to 67% from 14%. Australia's and Brazil's combined share of world iron ore exports remained the same at 67% in 2009 compared with their revised share in 2008. Five countries represented more than 86% of world iron ore exports. In decreasing order of market share, Australia held 38%; Brazil, 28%; India, 12%; South Africa, 5%; and Canada, 3% (United Nations Conference on Trade and Development, 2010, p. 100–103).

In China, the State Administration of Taxation in the Ministry of Finance announced the rate of value-added tax for imported iron ore would be raised from 13% to 17%. This increase became effective beginning January 1, 2009 (TEX Report, The, 2009d). According to The TEX Report (2010), China, the world's leading importer of iron ore, imported 599 Mt of nonagglomerated iron ore and 30 Mt of agglomerated ore in 2009. The leading exporters of nonagglomerated ore to China were Australia (43%), Brazil (23%), India (18%), and South Africa (6%), with the remainder shared among more than 30 countries. The leading exporters of agglomerated ore to China were Brazil (25%), Canada (17%), Ukraine (12%), Russia (11%), and Kazakhstan (11%), with the remainder shared among more than 23 countries.

Mergers and Acquisitions.—In October, Cliffs exercised its right of first refusal and announced it would purchase Wabush Mines, with mine, rail, concentrating, pelletizing, and port operations in Newfoundland and Labrador, and Quebec Provinces, Canada. Cliffs planned to purchase Wabush Mines from the two other joint-venture partners—ArcelorMittal Dofasco (Hamilton, Ontario, Canada) (a subsidiary of ArcelorMittal) and U.S. Steel Canada (Hamilton, Ontario, Canada) (a subsidiary of U.S. Steel). The $88 million purchase would increase Cliffs' ownership in the operations to 100% from 26.8%. Wabush Mines has a production capacity of 5.6 Mt/yr and reportedly about 70 Mt of iron ore reserves (Cliffs Natural Resources Inc., 2009c).

In January, Vale announced a purchase and sale agreement with Rio Tinto to acquire 100% of the Corumbá open pit iron ore operations in the State of Mato Grosso do Sul, Brazil. The price for the iron ore assets was $750 million and included associated logistics assets—port and barges. The Corumbá Mine had a production capacity of 2.5 Mt/yr and reportedly had proven and probable reserves at yearend 2007 of 583 Mt with a 62.7% iron ore content. By mid-September, Vale completed the purchase of the iron ore mine, including associated transport operations on the Paraguay River. Vale announced tentative plans to increase production capacity at Corumbá to 15 Mt/yr at a cost of greater than $2 billion (Vale S.A., 2009b, c).

Chinalco, a Chinese state-owned enterprise, proposed a $19.5 billion investment in Rio Tinto. Approximately $7.2 billion of the investment would be in convertible bonds, which when exercised would give Chinalco 18% ownership of Rio Tinto (Wilson and others, 2009). Australia's Foreign Investment Review Board (FIRB) faced an inquiry by state representatives into the bid by Chinalco, as well as a bid by another Chinese state-run enterprise (Hunan Valin Iron and Steel Group Co. Ltd.) for 16.5% interest in Fortescue Metals. FIRB regulates foreign ownership in Australian companies and restricts control of natural resources by foreign entities (Wilshaw, 2009).

In June, a nonbinding agreement was signed between Rio Tinto and BHP Billiton to form a joint venture covering production for both companies' Western Australian iron ore assets. The 50–50 ownership was expected to enhance each company's profitability through combination of adjacent mines into a single operating unit, more efficient utilization of rail and port facilities, improvement in blending and product quality, optimization of future facilities growth and project development, and combination of staff functions within a single entity. This merger follows a breakdown of the proposed deal between Chinalco and Rio Tinto, in which the Chinese state-owned company would have obtained partial ownership of Rio Tinto (BHP Billiton Ltd., 2009b, p. 1; Brindal, 2009).

BHP Billiton and Rio Tinto later decided not to proceed with the formation of a joint-venture iron ore marketing entity and instead market production from their planned joint venture separately. The companies continued plans to merge production and development units to take advantage of significant operational synergies (BHP Billiton Ltd., 2009a). The decision to keep separate marketing entities may aid regulators in appraising the merger. CISA's unification of all Chinese iron ore purchasing in one organization may be seen, especially in light of the two major iron ore producing companies' withdrawal from a unified sales strategy, as a strong move away from balanced trade negotiations toward a market in which the purchaser (China) has greater control (Metal Bulletin, 2009f).

In April, China's National Development and Reform Commission approved the purchase of 260 million shares of Australia's Fortescue Metals by Hunan Valin for $A644.8 million (US$445 million). The share purchase agreement, giving Valin 17.3% of Fortescue capital ownership, was signed on February 25 and subsequently approved by the Australian Federal Treasurer. Hunan Valin planned to assist Fortescue in obtaining additional debt financing. It was estimated that an additional $3 to $4 billion would be required to raise production capacity to 90 Mt/yr from 50 Mt/yr at Fortescue's iron ore mines. Fortescue is the third largest producer of iron ore in Australia reportedly with 1.6 Gt of iron ore reserves in Western Australia's Pilbara Region (Fortescue Metals Group Ltd., 2009).

In an effort to acquire additional equity interest in Australian iron ore resources, Chinese investors sought and received approval from Australia's FIRB for Anshan Iron & Steel Group to increase its equity ownership of Gindalbie Metals Ltd. to 36.28% from 12.6%. Gindalbie was developing the Karara iron ore project in Western Australia, with plans for port development at Oakajee and a joint-venture pellet plant in China (TEX Report, The, 2009b; Wall Street Journal, The, 2009). FIRB also approved a $246 million deal between Centrex Metals Ltd. (Adelaide, Australia) and Wuhan Iron & Steel Co. (WISCO). Chinese Government-owned WISCO was then able to take a 60% stake in iron ore rights to five Centrex tenements on the Eyre Peninsula in South Australia. WISCO planned to invest an additional $169 million in staged payments linked to achieving JORC-inferred resources of up to 2 Gt (Mining Journal, 2009e). Centrex also received approval from FIRB for a joint venture with Baotou Steel Group, a Chinese state-owned entity headquartered in Inner Mongolia. The 50–50 magnetite joint venture planned to develop tenements on the Eyre Peninsula, with potential for production of between 3 Mt/yr and 5 Mt/yr (Metal Bulletin, 2009a).

World Review

Afghanistan.—The Ministry of Mines of Afghanistan requested expressions of interest for the Hajigak iron deposit. The deposit was estimated to contain about 1.8 Gt of iron ore resources at a grade of 62% iron content within 16 ore bodies along a strike length of 32 kilometers (km). The deposit is located about 130 km west of Kabul. Successful applicants were to be notified by the Ministry of Mines on or before May 20, 2009, and would receive a bid package for the Hajigak deposit (Mining Journal, 2009c). The bidding was later reopened in early 2010 in order to improve transparency issues related to the first bidding process (Rupert and Najafizada, 2010).

Australia.—BHP Billiton announced full-year production figures for 2009. BHP Billiton's share of salable quantities of iron ore (wet) were as follows (Australia, unless otherwise specified)—Area C Joint Venture (JV) (85% owned), 37.0 Mt; Goldsworthy JV (85% owned), 1.7 Mt; Mt. Newman JV and Jimblebar (85% owned), 30.4 Mt; Samarco (Brazil) (50% owned), 8.9 Mt; and Yandi JV (85% owned), 39.9 Mt. BHP Billiton's share of total world mine production was 117.8 Mt in 2009, a slight increase from that of 2008 (BHP Billiton Ltd., 2010a, p. 4).

BHP Billiton completed its Rapid Growth Project 4 with the opening of the Newman Mining Hub—the company's center for mining, crushing, and screening in the Eastern Pilbara region of Western Australia. The $1.85 billion project was designed to raise BHP Billiton's production capacity in the Pilbara by 26 Mt/yr to 155 Mt/yr, part of an overall expansion plan to raise iron ore production to 300 Mt/yr by 2015. Rapid Growth Project 5, a $4.80 billion project with engineering 85% complete and construction 25% complete by yearend 2009, was expected to add 50 Mt/yr to system capacity by the second half of 2011 (Skillings Mining Review, 2009a; BHP Billiton Ltd., 2010b).

Rio Tinto announced full-year production figures for 2009. Rio Tinto's share of salable quantities of iron ore plus pellets were as follows (Australia, unless otherwise specified)—Channar (60% owned), 6.6 Mt; Corumbá (Brazil), 1.5 Mt; Eastern Range, 9.3 Mt; Hamersley, 106.8 Mt; Hope Downs (50% owned), 10.3 Mt; Iron Ore Company of Canada (IOC) (58.7% owned), 8.1 Mt; and Robe River (53% owned), 28.8 Mt. Rio Tinto's share of total world mine production was 171.5 Mt, a 12% increase from that of 2008 (Rio Tinto plc, 2010, p. 166).

Rio Tinto announced that its HIsmelt pig iron plant (Kwinana, Western Australia) would be placed on care and maintenance for 1 year at the end of March. The Kwinana plant, with design capacity of 800,000 t/yr, used proprietary, direct-smelting technology to produce pig iron from high-phosphorus iron ore fines and noncoking coal. Rio Tinto (60%), United States' Nucor Corp. (25%), Japan's Mitsubishi Corp. (10%), and China's Shougang Corp. (5%) jointly own the plant (TEX Report, The, 2009a).

Atlas Iron Ltd. (West Perth) secured additional berthing facilities at Port Hedland to bring its production capacity to 6 Mt/yr. The Utah Point facilities were under construction and were expected to begin exports of Atlas iron ore in April 2010. Atlas began mining iron ore from its 100%-owned Pardoo Mine in 2008, and shipped its first direct shipping ore (DSO) in December 2008 (Atlas Iron Ltd., 2009).

Fortescue Metals decided to fund an expansion of its Pilbara operations after a deal with Chinese investors failed. The proposed $6 billion funding requirement would be used to double iron ore output to 90 Mt/yr. Original funding with Chinese investors had been tied to an agreement by Fortescue to sell 20 Mt of iron ore to Chinese steel mills at a 35% reduction on the previous year's prices (Welch, 2009).

Brazil.—In 2009, Vale reported iron ore production was 238 Mt (includes Vale's Samarco, which was a joint venture until becoming fully owned by Vale in September)—a 21% decrease compared with that of 2008. Vale's share of salable quantities of iron ore was as follows, in decreasing order of tonnage—Southeastern System, 89.5 Mt; Carajás, 84.6 Mt; Southern System, 55.2 Mt; and Samarco, 8.6 Mt. Vale pellet production in 2009 was 23.9 Mt—a 47% decrease compared with that of 2008. The breakdown of salable quantities of iron ore pellets was as follows, in decreasing order of pellet production—Samarco, 8.0 Mt; Nibrasco, 5.8 Mt; Tubarão I and II, 3.9 Mt; Vargem Grande, 2.2 Mt; Kobrasco, 1.7 Mt; Itabrasco, 1.5 Mt; Hispanobras, 0.6 Mt; Fábrica, 0.2 Mt; and São Luís, 3,000 t. Of this pellet production, 14.0 Mt was blast furnace pellets and 9.8 Mt was direct reduction pellets. A large part of pellet production in 2009 was shut down owing to reduced global demand and a desire to avoid excessive inventory buildup. The Vargem Grande pellet plant continued to ramp up production and construction continued on two new plants: Tubarão VIII (16.5 Mt/yr pellet production capacity) and another plant in Oman (9.8 Mt/yr direct reduction pellet production capacity) (Vale S.A., 2010, p. 2, 3).

MMX Mineração e Metálicos S.A. (Rio de Janeiro) announced that resources at its Serra Azul Mine had increased five-fold to 515 Mt, with measured and indicated resources totaling 381 Mt (MMX Mineração e Metálicos S.A., 2009).

Canada.—IOC [owned jointly by Labrador Iron Ore Royalty Income Fund (15.1%), Mitsubishi Corporation (26.18%), and Rio Tinto (58.72%)] produced 5.7 Mt of iron ore concentrates and 8.1 Mt of iron ore pellets. ArcelorMittal Mines Canada (formerly Québec Cartier Mining Company) produced 13.1 Mt of iron ore concentrates and pellets. Wabush Mines Ltd. [owned jointly by ArcelorMittal (28.6%), Cliffs (26.8%), and U.S. Steel Canada (44.6%)] produced 2.7 Mt of iron ore pellets (ArcelorMittal, 2010, p. 53; Cliffs Natural Resources Inc., 2010, p. 57; Skillings Mining Review, 2010b, p. 10–11).

Consolidated Thompson Iron Mines Ltd. (Toronto, Canada) signed a letter of agreement with China's WISCO for the investment of $240 million in return for 19.9% of the shares of Consolidated Thompson. WISCO would also receive a 25% interest in the company incorporated to operate the future Bloom Lake iron ore mine in Quebec. Bloom Lake planned to produce 8 Mt/yr of iron ore, with expansion potential to 16 Mt/yr. Initial startup, although planned for late 2009, was postponed to 2010 (Consolidated Thompson Iron Mines Ltd., 2009).

Labrador Iron Mines (LIM) Holdings Ltd. (Toronto, Ontario) acquired an additional 50 Mt of DSO in the Province of Quebec. The deal was comprised of five separate transactions, in which Schefferville Mines Inc. (a fully owned subsidiary of LIM) obtained rights to several properties in different stages of exploration and development. The DSO properties are located near the company's planned western Labrador operations, which were scheduled to begin production in mid-2010 (Gordon, 2009).

China.—In June, it was reported that China discovered a massive iron ore deposit with 3 Gt of iron ore reported reserves in the northeastern province of Liaoning. The Dataigou deposit has an ore grade of between 25% and 62% iron and was located between 1.2 and 2.0 km below the surface.

China continued to report new project developments in advance of the upcoming 2010 iron ore price negotiations. It was reported that an iron ore deposit with 1 Gt of reserves was discovered in Luannan, Tangshan City, Hebei Province, in the northern part of the country. The Macheng deposit was reported to contain an average grade of 35% iron and was located between 100 and 600 meters below the surface. The Hebei Government reported that the deposit would be developed by Hebei Iron & Steel Group, the country's second leading steel producer (Skillings Mining Review, 2010a).

Congo (Brazzaville).—Xstrata plc (Zug, Switzerland) planned to invest $50 million to explore the Zanaga iron ore deposit. Zanaga is considered a world-class deposit and, if the results of the prefeasibility study were sufficiently encouraging, Xstrata planned to purchase the property and begin operations as soon as possible (Reuters, 2009).

Liberia.—Members of the country's parliament raised concerns related to the $2.6 billion agreement approving the development of the Bong iron ore deposit by China Union Holdings Ltd. (Shenzhen, China). Final approval was being withheld until issues relating to the basis for some tax exemptions were clarified (Mining Journal, 2009a). ArcelorMittal reported a planned $1.5 billion iron ore mine startup would be delayed owing to the downturn of the global economy and its effect on the steel market. ArcelorMittal still planned to make its first iron ore shipment from the Nimba Mine in the third quarter of 2011, and construction and development work would start during 2010 (Biesheuvel, 2010).

African Aura Mining Inc. (Vancouver, British Columbia, Canada) reported inferred mineral resource of 1.08 Gt containing an average of 38% of iron ore at the Company's Putu joint venture with Severstal. The Putu iron ore project is 38.5% owned by African Aura. A prefeasibility study was expected to be completed (African Aura Mining Inc., 2010, p. 1, 3, 6).

Peru.—Shougang Group (China), the parent company of Shougang Hierro Peru S.A., announced plans to invest $1 billion to double iron ore production capacity at its Peruvian iron ore operations by 2010. The iron ore production capacity was to be raised to 10 Mt/yr (Skillings Mining Review, 2009f).

Russia.—In mid-January, Mikhailovsky Mining & Processing (MGOK), owned by Metalloinvest Holding Co. (Moscow, Russia), resumed iron ore pellet production, which it had shut down to perform processing plant maintenance during a decline in iron ore market demand. MGOK had shipped stockpiled pellets while production was idled at the Lebedinsky and Mikhailovsky Mines since November 2008 (Interfax Ltd.—Russia & CIS—Metals & Mining Weekly, 2009).

OJSC Magnitogorsk Iron & Steel Works (Magnitogorsk, Russia) announced the startup of iron ore production at the Sosnovsky Mine in the Chelyabinsk Region. Reserves at the Sosnovsky deposit were estimated to be 70 Mt with a full production rate of between 2.0 Mt/yr and 2.5 Mt/yr, with 1 Mt/yr of sinter produced by dry magnetic separation. Mining rates of 370 Mt/yr and 500 Mt/yr were anticipated for 2009 and 2010, respectively (OJSC Magnitogorsk Iron & Steel Works, 2009).

Saudi Arabia.—London Mining Plc (London, United Kingdom) reported 157 Mt of ore resources with an average grade of 41.1% iron at the Wadi Sawawin prospect. The feasibility study suggested a run-of-mine production rate of 11.6 Mt/yr with an ability to produce 5.5 Mt/yr of direct-reduction iron pellets. The initial capital costs were estimated to be $1.8 billion. London Mining would develop the project with Saudi Arabia's National Mining Co. (Mining Journal, 2009d).

South Africa.—Kumba Iron Ore Ltd. (Centurion), the fourth leading supplier of iron ore for the seaborne trade, continued work on the Kolomela Mine, formerly known as the Sishen South Mine. The new mine, located 70 km southwest of the existing Sishen Mine, was expected to begin producing in 2012, with an annual production capacity of 9 Mt (Creamer, 2009).

Sweden.—At Luossavaara-Kiirunavaara Aktiebolag (LKAB) (Luleå) iron ore pellet production decreased to 14.7 Mt from 19.9 Mt in 2008. Pellet production was most of the total production, although 3.0 Mt of fines and minor special products were produced, a decrease in production of this material from 3.9 Mt in 2008. Decreased production resulted from all six pellet plants being closed intermittently during the first half of the year owing to declining market conditions. LKAB announced Kiruna's proven ore reserves to be 598 Mt at 48.6% iron content, and probable ore reserves of an additional 76 Mt at 46.4% iron content. The company reported Malmberget's proven ore reserves to be 298 Mt at 43.8% iron content, and probable ore reserves of 52 Mt at 37.8% iron content (Luossavaara-Kiirunavaara Aktiebolag, 2010, p. 5, 19).

Venezuela.—The Venezuelan Government unilaterally assumed exclusive control of the Materiales Siderúrgicos SA (Matesi) 1.5-Mt/yr hot briquetted iron (HBI) plant, formerly owned by Tenaris SA (Luxembourg). Three other privately owned hot briquetted iron producers were in negotiations for the nationalization of their holdings. Later in the year, following nationalization of several HBI plants, extremely low levels of HBI production were reported. Technical problems, labor issues, and output cuts caused by low prices and decreasing demand for product all contributed to these lower production levels (Weik, 2009a, b).

Outlook

It appeared that U.S. production in 2010 would increase almost to 2008 levels, and indications were that recovery from the strong economic downturn would continue into 2011 with steel and iron ore production returning to tonnages seen in the previous decade. Most U.S. iron ore production is sold directly to the domestic steel industry, although a large amount of domestic ore is shipped to Canada and small amounts are generally exported to other countries. Neither the domestic dependence nor the pattern of exports to Canada is expected to change in the near future, although changes in ownership of some steel plants have led to minor changes in the countries from which iron ore is imported.

Trends in the steel industry are provided in the "Outlook" section in the Iron and Steel chapter of the 2009 USGS Minerals Yearbook, volume I, Metals and Minerals. The development of projects, using new and existing direct reduction technology being developed in northern Minnesota, was expected to encourage growth of the U.S. iron ore industry within the next few years, as developments such as Steel Dynamics' Mesabi Nugget project comes to full production and Essar Steel's Minnesota Iron project is built.

The increase in Chinese iron ore imports in 2009 was a major indicator for growth in the global iron ore industry. Overall world trade in iron ore increased and international imports of iron ore and production of iron ore and pig iron—key indicators of iron ore consumption—pointed toward continued dependence by the global iron ore industry on increasing Chinese iron ore consumption. China was becoming increasingly involved in overseas projects in Australia and on the African continent through equity participation, which may well affect the balance of supply and demand for iron ore in the midterm. Downward price pressures would be anticipated as China acquires additional sources of supply, which may help to offset reduced supply from India, where it is expected that the domestic steel industry will take a larger share of iron ore production.

Following the economic downturn, which continued through most of 2009, the annual benchmark system of pricing lost its predominance in annual global iron ore sales. It is expected that more frequent benchmarking and indices developed based on spot sales will become a much stronger factor in the determination of future pricing. The possibility of developing a commodity exchange for the sale of iron ore still remains many years in the future. The new pricing system, for the short term, appears to give an advantage to the few major iron ore producers with respect to the many steel companies needing to make purchases.

Development of new iron ore mines in the next few years can be expected to add production capacity faster than the growth of demand, if those projects already considered strongly probable of coming onstream in the next few years actually do. Although supply is expected to remain tight in relation to demand, some easing of the supply deficit of iron ore needed to satisfy the iron ore requirements of China and India's growing steel industries can be expected. This would possibly lead to a leveling off of price growth in 2010 through 2013.

New developments and growth of DRI technology would allow the iron ore industry to become a major supplier to an expanding DRI sector, as well as to existing customers—the integrated steel plants. Coastal U.S. steel producers already rely on imported DRI to supply a quality raw-material input to help meet steel alloy purity specifications, which cannot be obtained solely using traditional scrap. However, even in the event of strong global DRI growth during the next decade, DRI would be able to replace only a small portion of the world's blast furnace production. Although no new "greenfield" pig iron facilities have been built in the United States in the past 30 years, and owing in part to the continued slow growth in the DRI market, the blast furnace, with its need for an assured supply of iron ore, is expected to remain the mainstay of the iron and steel industry in the immediate future.

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TABLE 1

SALIENT IRON ORE STATISTICS[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

		2005	2006	2007	2008	2009
United States, iron ore, usable, less than 5% manganese:[2]						
Production		54,300	52,700	52,500	53,600	26,700
Shipments:						
Quantity		53,200	52,700	50,900	53,600 [r]	27,600
Value		2,370,000	2,840,000	3,040,000	3,770,000	2,560,000
Average value at mines	dollars per metric ton	44.50	53.88	59.64	70.43	92.76
Exports:						
Quantity		11,800	8,270	9,310	11,100	3,920
Value		584,000	636,000	718,000	1,240,000	356,000
Imports for consumption:						
Quantity		13,000	11,500	9,400	9,250	3,870
Value		532,000	611,000	543,000	918,000	376,000
Consumption, iron ore and agglomerates		60,100	58,200	54,700	51,900	31,000
Stocks, December 31:						
At mines, plants and loading docks[3]		2,040	1,650 [4]	2,090 [4]	4,070 [4]	5,060 [4]
At receiving docks[5]		(6)	(6)	(6)	(6)	(6)
At consuming plants		(6)	(6)	(6)	(6)	(6)
Total[7]		(6)	(6)	(6)	(6)	(6)
Additional stocks, December 31:						
Crude ore at mines and plants		915	1,140 [4]	749 [4]	947 [4]	580 [4]
Unagglomerated concentrates for pelletizing plants		1,870	1,260	1,550	1,320	896
World, production[8]		1,550,000	1,840,000	2,040,000	2,210,000 [r]	2,240,000 [e]

[e] Estimated. [r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Direct-shipping ore, concentrates, agglomerates, and byproduct ore.

[3] Excludes byproduct ore.

[4] Crude ore stocks and unagglomerated concentrates for pelletizing plants removed. Marketable stocks only.

[5] Transfer and (or) receiving docks of lower Great Lake ports.

[6] American Iron and Steel Institute no longer collects this data as of 2004.

[7] Sum of stocks at mines, consuming plants, and U.S. docks.

[8] Gross weight.

TABLE 2
EMPLOYMENT AT IRON ORE MINES AND BENEFICIATING PLANTS, QUANTITY AND TENOR OF ORE PRODUCED, AND AVERAGE OUTPUT PER WORKER HOUR IN THE UNITED STATES IN 2009, BY DISTRICT AND STATE[1]

			Production				Average quantity per worker hour (metric tons)		
District and State	Average number of employees	Worker hours (thousands)	Crude ore (thousand metric tons)	Usable ore (thousand metric tons)	Iron contained in usable ore (thousand metric tons)	Iron content natural (percent)	Crude ore	Usable ore	Iron contained
Lake Superior:									
Michigan[2]	1,170	2,430	21,800	8,300	5,000	60.3	8.96	3.41	2.06
Minnesota	2,300	4,430	59,000	18,400	11,500	62.8	13.32	4.15	2.61
Total or average	3,470	6,860	80,800	26,700	16,500	62.0	11.78	3.89	2.41
Other States[3]	56	116	14	14	8	54.0	0.12	0.12	0.07
Grand total or average	3,530	6,980	80,800	26,700	16,500	62.0	11.58	3.83	2.37

[1] Data are rounded to no more than three significant digits, except "Average per worker hour, crude ore" may not add to totals shown.

[2] Does not include professional or clerical workers at mines, pelletizing plants, maintenance shops, or research lab workers.

[3] Includes California and South Dakota.

TABLE 3
CRUDE IRON ORE MINED IN THE UNITED STATES IN 2009, BY DISTRICT, STATE, AND MINING METHOD[1, 2]

District and State	Number of mines	Open pit (thousand metric tons)	Underground (thousand metric tons)	Total (thousand metric tons)
Lake Superior:				
Michigan	2	21,800	--	21,800
Minnesota	6	59,000	--	59,000
Total	8	80,800	--	80,800
Other States	4	14	--	14
Grand total	12	80,800	--	80,800

-- Zero.

[1] Includes some byproduct ore. Excludes ore containing 5% or more manganese.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 4

USABLE IRON ORE PRODUCED IN THE UNITED STATES IN 2009, BY DISTRICT, STATE, AND TYPE OF PRODUCT[1, 2]

(Thousand metric tons)

District and State	Direct shipping ore	Concentrates	Sinter	Other agglomerates[3]	Total
Lake Superior:					
Michigan	2	--	--	8,300	8,300
Minnesota	--	271	65	18,000	18,400
Total	2	271	65	26,300	26,700
Other States[4]	--	14	--	--	14
Grand total	2	285	65	26,300	26,700

-- Zero.

[1] Excludes ore containing 5% or more manganese.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Data may include pellet chips, screenings, and sinter.

[4] Includes California and South Dakota.

TABLE 5

SHIPMENTS OF USABLE IRON ORE FROM MINES IN THE UNITED STATES IN 2009[1, 2]

	Gross weight of ore shipped (thousand metric tons)					Average iron content, natural	
District and State	Direct shipping ore	Concentrates	Sinter	Other agglomerates	Total	(percent)	Value (thousands)
Lake Superior:							
Michigan	2	--	--	8,870 [3]	8,870 [3]	60.3	W
Minnesota	--	271	77	18,400	18,700	62.8	W
Total reportable or average	2	271	77	27,200	27,600	62.0	$2,560,000
Other States[4]	--	14	--	--	14	54.0	921
Grand total or average	2	285	77	27,200	27,600	62.0	2,560,000

W Withheld to avoid disclosing company proprietary data; included in "Total reportable or average." -- Zero.

[1] Includes byproduct ore. Excludes ore containing 5% or more manganese.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Source reported to Securities and Exchange Commission.

[4] Includes California and South Dakota.

TABLE 6
IRON ORE-PRODUCING MINES IN THE UNITED STATES IN 2009

State and mine	County	Operator	Source of iron ore
California:			
Baxter Mine	San Bernardino	Hahm International Inc.	Quarried ore.
Dredge 21	Yuba	Cal Sierra Development Inc.	Dredged sands.
Silverlake Mine	San Bernardino	Hahm International Inc.	Quarried ore.
Michigan:			
Empire	Marquette	Cliffs Natural Resources Inc.	Magnetite taconite ore.
Tilden	do.	do.	Hematite-magnetite taconite ore.
Minnesota:			
Hibbing Taconite	Saint Louis	do.	Magnetite taconite ore.
Keewatin Taconite	do.	United States Steel Corporation	Do.
Mesabi Chief Plant	do.	Magnetation, Inc.	Hematite tailings.
Minntac	do.	United States Steel Corporation	Magnetite taconite ore.
Minorca	do.	ArcelorMittal	Do.
Northshore	do.	Cliffs Natural Resources Inc.	Do.
United Taconite	do.	do.	Do.
South Dakota, CF & I Pit	Lawrence	Pete Lien & Sons Inc.	Quarried ore.

Do., do. Ditto.

TABLE 7
CONSUMPTION OF IRON ORE AT U.S. IRON AND STEEL PLANTS, BY TYPE OF PRODUCT[1]

(Thousand metric tons)

Type of product	2008	2009
Blast furnaces:		
Direct-shipping ore	--	--
Pellets	43,800	26,200
Sinter[2]	6,380	3,720
Total	50,200	29,900
Steelmaking furnaces:		
Direct-shipping ore	465	327
Sinter[2]	118	91
Total	583	417
Grand total	50,700	30,400

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes briquettes, nodules, and other.

Source: American Iron and Steel Institute.

TABLE 8

U.S. CONSUMPTION OF IRON ORE FOR DIRECT-REDUCED IRON AND NONSTEEL END USES[1, 2]

(Thousand metric tons)

Year	Direct-reduced iron for steelmaking[3]	Nonsteel end uses[4]	Total
2005	330	928	1,260
2006	360	867	1,230
2007	375	699	1,070
2008	390	734	1,120
2009	--	603	603

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes agglomerates. Excludes ore containing 5% or more manganese.

[3] U.S. Geological Survey estimates based on production reports compiled by Midrex Corp.

[4] An estimate, which includes iron ore consumed in production of cement and iron ore shipped for use in manufacturing paint, ferrites, heavy media, cattle feed, refractory and weighing materials, and for use in lead smelting.

TABLE 9

U.S. EXPORTS OF IRON ORE, BY COUNTRY OF DESTINATION[1, 2]

(Thousand metric tons and thousand dollars)

Country	2008		2009	
	Quantity	Value	Quantity	Value
Algeria	80	$7,690	--	--
Belgium	218	20,900	194	$18,600
Canada	9,030 r	1,020,000	3,060	276,000
China	91	7,210	99	5,800
Colombia	12	946	20	1,210
Czech Republic	83	7,930	--	--
France	210	20,100	179	17,200
Germany	156	14,900	234	22,400
Malaysia	25	499	1	60
Mexico	328	43,200	70	8,730
Poland	103	9,890	--	--
Romania	129	12,400	--	--
Serbia	51	7,850	--	--
Slovakia	505	61,700	--	--
South Africa	--	--	53	5,050
Spain	103	9,770	--	--
Sweden	4	291	6	427
Other[3]	13	1,620 r	6	442
Total	11,100 r	1,240,000 r	3,920	356,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes agglomerates.

[3] Includes all countries with less than 5,000 metric tons of exports from the United States in 2008 and 2009. This represents 13 countries in 2008 and 16 countries in 2009.

Source: U.S. Census Bureau.

TABLE 10

U.S. EXPORTS OF IRON ORE, BY TYPE OF PRODUCT[1, 2]

	2008			2009		
Type of product	Quantity (thousand metric tons)	Value (thousands)	Unit value[3, 4] (dollars per metric ton)	Quantity (thousand metric tons)	Value (thousands)	Unit value[3, 4] (dollars per metric ton)
Concentrates	142	$13,000	91.24	123	$7,850	63.84
Coarse ores	45	1,160	25.63	4	182	45.50
Fine ores	136 r	12,500 r	91.71 r	25	1,560	62.52
Pellets	10,800	1,220,000	112.64	3,760	346,000	92.10
Briquettes	(5)	4	79.15	3	259	86.33
Other agglomerates	19	1,100	13.37	(5)	22	80.00
Roasted pyrites	1	102	90.66	1	71	71.00
Total	11,100 r	1,240,000 r	111.67 r	3,920	356,000	90.97

r Revised.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Includes agglomerates.

[3] Unit values shown are calculated from unrounded data.

[4] Weighted average calculated from unrounded data by dividing total value by total tonnage.

[5] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 11

U.S. IMPORTS OF IRON ORE, BY COUNTRY AND TYPE OF PRODUCT[1, 2]

Country and type of product	2008 Quantity (thousand metric tons)	2008 Value (thousands)	2008 Unit value[3, 4] (dollars per metric ton)	2009 Quantity (thousand metric tons)	2009 Value (thousands)	2009 Unit value[3, 4] (dollars per metric ton)
Country:						
Bosnia and Herzegovina	23	$1,570	68.43	--	--	--
Brazil	2,620	216,000	82.45	188	$13,100	69.65
Canada	5,900	645,000	109.35	3,140	323,000	102.70
Chile	215	16,800	78.25	203	16,100	79.14
China	14	266	19.00	(5)	2	33.33
Finland	6	233	38.83	6	367	61.17
Mexico	52	4,290	82.56	55	4,610	83.73
Peru	59	3,100	52.59	34	1,670	49.03
Russia	127	16,000	126.06	136	8,240	60.60
South Africa	--	--	--	43	2,980	69.23
Sweden	88	4,540	51.59	31	3,190	102.74
Switzerland	70	5,410	77.29	--	--	--
United Kingdom	--	--	--	8	1,630	203.75
Venezuela	68	4,210	61.85	21	825	39.29
Other[6]	4	185	98.92	8	224	39.75
Total	9,250	918,000	99.26	3,870	376,000	96.97
Type of product:						
Concentrates	1,250	92,200	73.79	283	22,300	78.95
Coarse ores	48	1,970	41.10	16	2,330	145.50
Fine ores	1,980	149,000	75.59	466	34,900	74.91
Pellets	5,960	674,000	113.03	3,100	315,000	101.90
Briquettes	1	97	97.00	4	159	39.75
Other agglomerates	--	--	--	3	104	34.67
Roasted pyrites	12	537	44.75	6	367	61.17
Total	9,250	918,000	99.26	3,870	376,000	96.97

-- Zero.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Includes agglomerates.

[3] Unit values shown are calculated from unrounded data.

[4] Weighted average calculated from unrounded data by dividing total value by total tonnage.

[5] Less than ½ unit.

[6] Includes four countries with less than 5,000 metric tons of imports to the United States in both 2008 and 2009.

Source: U.S. Census Bureau.

TABLE 12
U.S. IMPORTS OF IRON ORE IN 2009, BY COUNTRY AND TYPE OF PRODUCT[1, 2]

(Thousand metric tons)

Country of origin	Concentrates	Coarse ores	Fine ores	Pellets	Briquettes and other agglomerates	Roasted pyrites	Total
Brazil	--	--	150	38	--	--	188
Canada	--	--	245	2,900	--	--	3,140
Chile	198	--	5	--	--	--	203
Finland	--	--	--	--	--	6	6
Mexico	52	--	--	--	3	--	55
Peru	--	--	29	5	--	--	34
Russia	--	--	--	136	--	--	136
South Africa	33	8	2	--	--	--	43
Sweden	--	--	31	--	--	--	31
United Kingdom	--	8	--	--	--	--	8
Venezuela	--	--	--	21	--	--	21
Other[3]	--	(4)	4	--	4	--	8
Total	283	16	466	3,100	7	6	3,870

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes agglomerates.

[3] Includes all countries with less than 5,000 metric tons of imports to the United States. This represents three countries.

[4] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 13
AVERAGE UNIT VALUE FOR SELECTED IMPORTS OF IRON ORE IN 2009[1]

Type of product	Country of origin	Average unit value[2] (dollars per metric ton, gross weight)
Concentrates	Chile	79.53
Do.	Mexico	86.33
Do.	South Africa	64.28
Fine ores	Brazil	63.96
Do.	Canada	82.29
Do.	Peru	47.97
Do.	Sweden	102.12
Pellets	Brazil	93.23
Do.	Canada	104.44
Do.	Russia	60.68

Do. Ditto.

[1] Includes agglomerates.

[2] Weighted averages of individual customs values.

Source: U.S. Census Bureau.

TABLE 14

U.S. IMPORTS OF IRON ORE, BY CUSTOMS DISTRICT[1, 2]

(Thousand metric tons and thousand dollars)

	2008		2009	
Customs district	Quantity	Value	Quantity	Value
Baltimore, MD	3,590	$338,000	781	$67,400
Buffalo, NY	1	43	--	--
Charleston, SC	28	647	6	151
Chicago, IL	1,160	81,600	637	45,000
Cleveland, OH	3,160	384,000	1,860	213,000
Detroit, MI	(3)	4	--	--
Houston-Galveston, TX	51	5,870	38	3,510
Los Angeles, CA	--	--	(3)	1
Minneapolis, MN	103	9,660	--	--
Mobile, AL	74	4,570	28	2,270
New Orleans, LA	1,020	91,400	465	41,400
New York, NY	1	28	--	--
Nogales, AZ	--	--	3	175
Norfolk, VA	10	649	--	--
Ogdensburg, NY	12	223	18	325
Philadelphia, PA	6	249	6	367
Port Arthur, TX	--	--	8	1,630
Seattle, WA	--	--	28	513
Tampa, FL	24	1,490	--	--
Total	9,250	918,000	3,870	376,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes agglomerates.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 15

U.S. IMPORTS OF PELLETS, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2008		2009	
Country	Quantity	Value	Quantity	Value
Bosnia and Herzegovina	23	$1,570	--	--
Brazil	616	65,600	38	$3,510
Canada	5,240	602,000	2,900	303,000
Peru	18	736	5	283
Russia	--	--	136	8,240
Venezuela	68	4,210	21	825
Total	5,960	674,000	3,100	315,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 16
SELECTED PRICES FOR IRON ORE IN THE JAPANESE MARKET[1]

(Cents per dry long ton unit of iron unless otherwise specified)

Country and producer	Ore types	April 1-March 31 Fiscal year 2008	Fiscal year 2009
Australia:			
Hamersley Iron Proprietary Limited and Mount Newman Mining Company Proprietary Limited[2]	Lump ore	201.69	112.00
Do.[2]	Fines	144.66	97.00
Robe River Iron Associates[2]	do.	115.30	77.31
BHP Billiton (Yandi)[2]	do.	144.66	97.00
Fortescue Metals Group	do.	NA	94.00
Brazil:			
Companhia Nipo-Brasileira de Pelotizacao (Nibrasco)[2]	Pellets	213.59	110.43
Vale S.A. (Carajás)[2]	Fines	125.17	89.87
Vale S.A. (Itabira)[2]	do.	118.98	85.43
Mineraçoes Brasileiras Reunidas Societe Anonyme	Lump ore	181.78	100.94
Do.	Fines	NA	NA
Samarco Mineracâo Societe Anonyme	Pellets	213.59 [3]	110.43 [3]
Canada, Iron Ore Company of Canada (Carol Lake)	Concentrates	117.27	84.20
Chile:			
Minera del Pacifico Societe Anonyme (Huasco)	Pellets	104.99	NA
Minera del Pacifico Societe Anonyme (El Romeral)	Fines	93.65	67.24
India:			
Minerals and Metals Trading Corporation (Bailadila)	Lump ore	198.68	110.33
Do.	Fines	141.12	94.62
Peru, Shougang Hierro Peru S.A.A.	Pellet feed	92.47	66.39
South Africa:			
Kumba Resources Limited (Iscor)	Lump ore	165.89	92.12
Assmang Limited	do.	163.92	91.02
Do.	Fines	108.05	72.45
Venezuela, Corporación Venezolana de Guayana[2]	Pellet feed	94.28	67.69

Do., do. Ditto. NA Not available.

[1] Free on board shipping port basis.

[2] Cents per dry metric ton unit.

[3] Blast furnace grade pellets.

Sources: Trust Fund Project on Iron Ore Information, Iron Ore Statistics–October 2010. The TEX Report, Iron Ore Manual 2009.

TABLE 17

IRON ORE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

	Gross weight[3]					Metal content[4]				
Country[5]	2005	2006	2007	2008	2009[e]	2005	2006	2007	2008	2009[e]
Algeria	1,579	2,340	1,982	2,077	2,000	800 [e]	1,180	1,000 [e]	1,050	1,040
Australia	262,000	275,000	299,000	342,000	394,000	163,000	171,000 [r]	194,000 [r]	209,000	228,000
Austria	2,048	2,093 [r]	2,153	2,033 [r]	1,500	665 [r]	669 [r]	689 [r]	650 [r]	480
Azerbaijan	7	11	18 [r]	28 [r]	-- [6]	4 [e]	6 [e]	9 [e]	14 [r, e]	--
Bosnia and Herzegovina	3,177	3,440	2,944	2,667 [r]	2,600	1,500	1,450	1,240	1,200 [r, e]	1,100
Brazil	281,462	317,800	354,674	351,246 [r]	300,000 [p]	186,891	211,020	235,504 [r]	233,200 [r]	199,200 [p, 6]
Canada[7]	30,387	33,543	32,744	31,273	31,700	19,333	21,341	20,800	19,700 [e]	19,700
Chile	7,862	8,628	8,818	9,316	8,242 [6]	4,707	5,235	5,379	5,670	5,006 [6]
China[e, 8]	420,000	601,000	707,000	824,000	880,000	138,000	198,000	233,000	270,000	280,000
Colombia	608	644	624	475 [r]	500	325	351	350	200 [r]	200
Egypt[e]	1,590	1,600	2,185 [6]	1,811 [6]	1,800	800	800	1,100	910	900
Germany[9]	362	412	422	455 [r]	350	38	44	44	48 [r, e]	37
Greece[e, 10]	1,500	1,500	1,500	1,500	1,500	575	575	575	575	570
Guatemala	11	7	31 [r]	(11) [r]	5 [6]	7 [r, e]	5 [r, e]	20 [r, e]	(11) [r, e]	4
India[e]	152,000	181,000	202,000	220,000	245,000	97,500	117,000	129,000	142,000	157,000
Indonesia	32	88	61	65 [e]	63	18	50	35	37 [e]	36
Iran[e, 12]	19,000	26,244 [6]	31,538 [6]	32,000	33,000	9,000	13,000	15,000	15,000	16,000
Kazakhstan	19,471	22,263	23,834	22,700 [e]	22,290 [6]	11,100	12,700	13,600	13,000 [e]	12,800
Kenya[e]	(11) [6]	(11)	(11)	(11)	(11)	(11) [6]	(11)	(11)	(11)	(11)
Korea, North[e]	5,000	5,040	5,130	5,136 [r, 6]	5,000	1,400	1,400	1,400	1,488 [r, 6]	1,400
Korea, Republic of	213	227	291	366 [r]	360 [6]	119	155	163	205 [r]	200
Macedonia[e]	10	10	--	-- [6]	--	6	6	--	-- [6]	--
Malaysia	950	667	802	982 [r]	950	541 [e]	380 [e]	457 [e]	560 [r, e]	532
Mauritania	11,133	10,658	11,817	11,200 [r]	10,400 [6]	7,240 [r]	7,250 [r]	7,700 [r]	7,280 [r]	6,760
Mexico[13]	11,687	10,983	10,916	11,688	11,600	7,012	6,590	6,550	7,013	7,000
Mongolia	168	180	265	1,387	1,000	109	116	170	888	600
Morocco[e]	10	10	10	10	10	5	5	5	5	5
New Zealand[14]	2,270	2,146	1,723	2,020 [r]	2,000	1,260 [e]	1,220 [e]	982 [e]	1,200 [r, e]	1,200
Nigeria[e]	60	88 [6]	58 [6]	62 [6]	50	22	32	21	23	16
Norway	620	620	620	668 [r]	711 [6]	420	420	400 [e]	430 [e]	460
Pakistan[15]	50	130	207	250	270	25	65	104	125 [e]	135
Peru	6,810	7,138 [r]	7,614 [r]	7,823 [r]	6,698 [6]	4,638 [r]	4,862 [r]	5,186 [r]	5,244 [r]	4,490 [6]
Portugal[e, 16]	14	14	14	14 [r]	14	10	10	10	10 [r]	10
Romania	265	123	45	-- [r]	--	69	40	11	-- [r]	--

See footnotes at end of table.

TABLE 17—Continued

IRON ORE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[5]	Gross weight[3]					Metal content[4]				
	2005	2006	2007	2008	2009[e]	2005	2006	2007	2008	2009[e]
Russia	96,764	102,000	105,000	99,900	92,000 [6]	56,100 [e]	59,100 [e]	60,800 [e]	57,800 [e]	53,200
Slovakia	534	583	570	392	390	182	198	194	133	130
South Africa[17]	39,542	41,326	42,083 [r]	48,983	55,313 [6]	25,000 [e]	26,100 [e]	26,600 [e]	31,000 [e]	35,600
Sweden[e]	23,300	23,300	24,700	23,800 [6]	17,700	15,300	15,000	16,000	14,280 [r, 6]	11,500
Thailand	231	264	1,555	1,710 [r]	1,700	116	132	779 [r]	855 [r]	855
Tunisia	206	214	180 [r]	108 [r]	110	108 [e]	112 [e]	94	56 [r]	57
Turkey	4,598	3,785	4,849	4,700 [e]	4,000	2,450	2,000 [e]	2,600	2,500 [e]	2,100
Ukraine	68,570	74,000	77,900	72,700 [e]	66,476 [6]	37,700 [e]	40,700 [e]	42,800 [e]	40,000 [r, e]	36,500
United Kingdom	(11)	(11)	(11) [e]	(11)	--	(11)	(11)	(11) [e]	(11)	--
United States	54,329	52,749	52,489	53,560	26,696 [6]	34,202	33,274	33,068	33,769	16,550 [6]
Venezuela[e]	21,200	22,100	20,700	20,650 [6]	14,900	14,000	14,500	13,600	13,600	9,800
Vietnam	1,009	1,020	1,060 [e]	1,000 [e]	1,000	505	510	530 [e]	530 [e]	530
Zimbabwe	377	104	100 [e]	50 [e]	--	200 [e]	52 [e]	50 [e]	25 [e]	--
Total	1,550,000	1,840,000	2,040,000	2,210,000 [r]	2,240,000	843,000	969,000	1,070,000	1,130,000	1,110,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] Estimated data and world totals are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 22, 2010.

[3] Insofar as availability of sources permit, gross weight in this table represent the nonduplicative sum of marketable direct-shipping iron ores and iron ore concentrates; iron agglomerates produced from imported iron ores have been excluded under the assumption that the ore from which such materials are produced has been credited as marketable ore in the country where it was mined.

[4] Data represent actual reported weight of contained metal or are calculated from reported metal content. Estimated figures are based on latest available iron content reported, except for the following countries for which grades are U.S. Geological Survey estimates: Azerbaijan, Kazakhstan, North Korea, and Ukraine.

[5] In addition to the countries listed, Cuba may also produce iron ore, but definitive information on output levels, if any, is not available.

[6] Reported figure.

[7] Series represented gross weight and metal content of usable iron ore (including byproduct ore) actually produced, natural weight.

[8] China's gross weight iron ore production figures are significantly higher than that of other countries, because China reports crude ore production only with an average iron content of 33%, whereas other countries report production of usable ore.

[9] Iron ore is used domestically as an additive in cement and other construction materials but is of too low a grade to use in the steel industry.

[10] Nickeliferous iron ore.

[11] Less than ½ unit.

[12] Data are for year beginning March 21 of that stated.

[13] Gross weight calculated from reported iron content based on grade of 60% iron.

[14] Concentrates from titaniferous magnetite beach sands.

[15] Pakistan iron ore is based on a July-to-July fiscal year and 50% of production is used from each reported year.

[16] Includes manganiferous iron ore.

[17] Includes magnetite ore as follows, in thousand metric tons: 2005—2,957; 2006—3,830; 2007—3,781; 2008—3,987; and 2009—4,725.

TABLE 18

IRON ORE: WORLD PELLETIZING CAPACITY, BY CONTINENT AND COUNTRY IN 2009[1]

	Rated capacity, gross weight (million metric tons)
North America:	
Canada	27.5
Mexico	15.0 [e]
United States	56.6
Total	99.1
South America:	
Brazil	56.0 [e]
Chile	5.3 [r]
Peru	3.5
Venezuela	11.8 [e]
Total	76.6
Europe and Central Eurasia:	
Kazakhstan	8.4 [e]
Netherlands	4.4 [e]
Russia	31.4 [e]
Slovakia	0.4
Sweden	21.0
Turkey	1.5
Ukraine	33.5 [e]
Total	100.6
Asia:	
Bahrain	4.0
China	45.0 [e]
India	26.7 [r]
Iran	12.3 [e]
Japan	3.0
Total	91.0
Oceania, Australia	4.3
Grand total	371.6

[e]Estimated. [r]Revised.

[1]Data may not add to totals shown because of independent rounding.

Sources: International Iron and Steel Institute; United Nations Commission on Trade and Development, Trust Fund on Iron Ore Information; U.S. Geological Survey.

IRON OXIDE PIGMENTS

By Robert L. Virta

Domestic survey data were prepared by Hoa P. Phamdang, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2009, natural iron oxide pigment (IOP) production in the United States decreased compared with that of 2008. U.S. production data are withheld to avoid revealing company proprietary data. Finished natural and synthetic IOPs sold by processors decreased to 50,800 metric tons (t) valued at $74 million in 2009 from 83,300 t valued at $116 million in 2008. Exports of all grades of IOPs and hydroxides decreased to 17,000 t valued at $34 million in 2009 compared with 51,600 t valued at $43.9 million in 2008. Imports of natural and synthetic IOPs decreased to 106,000 t valued at $127 million in 2009 compared with 155,000 t valued at $164 million in 2008 (table 1).

Production

Natural IOPs are derived from hematite, which is a red iron oxide mineral; limonite, which varies from yellow to brown, such as ochers, siennas, and umbers; and magnetite, which is black iron oxide. Synthetic IOPs are manufactured using three methods: thermal decomposition of iron salts or iron compounds; precipitation of iron salts, usually accompanied by oxidation; and reduction of organic compounds by iron (Podolsky and Reid, 2006, p. 1458).

U.S. production data for crude (natural) IOPs sold or used in 2009 were developed by the U.S. Geological Survey (USGS) from a voluntary survey of three companies, of which all responded. Domestic production data collected through the USGS survey are withheld to avoid disclosing company proprietary data, but sales were less than 50,000 t in 2009. Production declined in 2009 compared with that of 2008.

In a second voluntary USGS survey, data were received from seven of eight known processing operations for finished (natural and synthetic) IOPs. These seven operations represented 74% of the tonnage shown in table 1. Data for the nonrespondent was estimated on the basis of prior-year levels of output and industry trends. Sales of finished pigments were 50,800 t valued at $74 million in 2009 compared with 83,300 t valued at $116 million in 2008.

Production data for finished IOPs are collected only from operations that process material, such as the crushing and grinding of natural IOPs or synthesize IOPs. Canvass data are not collected from operations that simply blend, mix, repackage, and (or) resell IOP material.

At least three U.S. companies produced regenerated iron oxide during steelmaking (table 2).

Iron oxide is obtained during steelmaking when steel is treated with hydrochloric acid to remove surface oxides. The spent pickle liquor is treated to recycle the acid, resulting in the formation of iron oxide. Regenerated iron oxide data were not included in table 1 because it must be processed before it is suitable for use in typical iron oxide pigment applications.

Alabama Pigments Co. completed construction of a new production facility at its McCalla, AL, site to process natural black iron oxide, specialty blended products, and agricultural products. The company also began to install three new blenders and four 100-ton dry bulk silos at the site (Alabama Pigments Co., 2009).

Consumption

End-use data for IOPs are not surveyed by the USGS or other organizations. Will (2008, p. 12) estimated that world consumption of natural IOPs and synthetic IOPs was 167,000 t and 1.13 million metric tons (Mt), respectively, in 2006. More recent data are unavailable, but the global economic downturn since 2008 likely resulted in decreased consumption of IOP in 2008 and 2009. Uses for natural IOPs were estimated to be construction materials (48%), coatings (42%), other unspecified applications (7%), and ceramic, glass, paint, paper, and plastic applications (3%). Uses for synthetic IOPs were estimated to be construction materials (48%), coatings (24%), other unspecified applications (21%), and ceramic, glass, paint, paper, and plastic applications (7%).

Construction materials included such concrete products as block, brick, or segmental retaining wall units; mortar; paving stones; precast products of various sizes or dimensions; ready-mixed concrete; and roofing tiles. IOPs are used almost exclusively to color decorative concrete, with the tinted concrete often being stamped so that it resembles brick, slate, stone, and many more shapes and forms found in nature, including wood (Pinto, 2008, p. 4, 6).

Sales of IOP in these construction markets were negatively affected by the sharp decline in domestic and foreign construction activity. In the United States, construction starts for new privately owned housing decreased to 555,000 units in 2009 from 905,000 units in 2008 (U.S. Census Bureau, 2010b). The value of all residential and commercial construction, both of which use tinted brick and concrete products, decreased to $937 billion in 2009 from $1.07 trillion in 2008 (U.S. Census Bureau, 2010a).

The second largest market for IOP is as a tint in paints and coatings. The paint and coatings market experienced a significant decline in shipments in 2009 owing to decreased construction and manufacturing activity during the economic recession. Shipments of total paint and allied products (comprising architectural coatings, original equipment manufacture product coatings, special-purpose coatings, and miscellaneous allied paint products) were 3.74 billion liters (988 million gallons) in 2009 compared with 4.62 billion liters (1.22 billion gallons) in 2008 (U.S. Census Bureau, 2010c).

Other end uses of IOPs included colorants for ceramics, glass, paper, plastics, rubber, and textiles; in foundry sands; and industrial chemicals, such as catalysts. Other applications were animal feed, cosmetics, ferrites, fertilizers, and magnetic ink and toner.

A major end use for regenerator iron oxides was ferrite ceramic magnets. There are two types of ferrites—soft, which do not retain magnetism permanently, and hard, which retain magnetism permanently. The latter are also referred to as permanent magnets. Uses of soft ferrites include computers, cores for radio frequency coils, inverter cores, memory cores, microwave communication systems, microwave ferrites for telecommunications, pot cores, rectangular modulus cores, television deflection yokes, and other industrial applications. Hard ferrites are used in flexible magnets, generators, loudspeakers, and motors.

Prices

The average annual producer price index (PPI) for IOPs under North American Industry Classification System code 325131–72 was 200.2 in 2009 (1983=100) compared with 209.8 in 2008. The PPI ranged between 197.7 and 201.2 in 2009 with the high being reached in August and the low in October. The PPI measured the average change in the selling prices charged by domestic producers of IOPs over time (U.S. Bureau of Labor Statistics, 2010).

LANXESS AG raised prices for several of its IOP products by as much as $250 per metric ton because of increases in costs for raw materials (LANXESS AG, 2009b).

Unit values for finished natural and synthetic IOP sold by domestic producers ranged from $0.36 to $3.24 per kilogram, with an average unit value of $1.46 per kilogram.

The average unit value of exports of pigment-grade IOP and hydroxides was $2.74 per kilogram in 2009 compared with $2.56 per kilogram in 2008. The average unit value of exports of other grades of IOP and hydroxides was $1.63 per kilogram in 2009 compared with $0.68 per kilogram in 2008. Unit values increased for export shipments to nearly all countries.

Unit values of imports of IOP and hydroxides ranged from $0.51 to $2.22 per kilogram, depending on the grade. The average unit value of all IOP imports combined was $1.19 per kilogram in 2009 compared with $1.05 per kilogram in 2008. The unit value of imported micaceous IOP declined and those for all other import grades either remained unchanged or increased.

Imports of natural IOP grades averaged $0.56 per kilogram in 2009, unchanged from 2008. The average value of U.S. imports of natural IOPs from Cyprus, the leading source, increased to $0.48 per kilogram in 2009 from $0.47 per kilogram in 2008. The value of natural IOP imports from Spain, the second leading source, decreased to $0.36 per kilogram from $0.59 per kilogram during the same period.

Synthetic IOP import grades averaged $1.20 per kilogram in 2009 compared with $1.07 per kilogram in 2008. The average value of U.S. imports of synthetic IOPs from China, the leading source, decreased to $0.91 per kilogram in 2009 from $0.93 per kilogram in 2008. The value of synthetic IOP imports from Germany, the second leading source, increased to $1.28 per kilogram from $1.20 per kilogram.

Foreign Trade

U.S. exports of pigment-grade IOPs and hydroxides in 2009 totaled 5,640 t valued at $15.5 million compared with 4,740 t valued at $12.1 million in 2008. China was the leading destination for exports of pigment-grade IOPs, accounting for 40% of the export tonnage. Exports of pigment-grade IOP increased to Asian markets.

Exports of other grades of IOPs and hydroxides were 11,300 t valued at $18.5 million in 2009 compared with 46,900 t valued at $31.8 million in 2008. Canada and Mexico were the major destinations for exports of other grades of IOPs and hydroxides, accounting for 79% of the export tonnage. Canada, China, and Mexico accounted for 94% of the decline in exports of other grades of IOP (table 3). The global recession resulted in decreased exports to Canada, Mexico, and European countries. In addition, China increased its IOP production in the past 4 to 5 years, resulting in lesser dependence on imports of IOP from the United States.

U.S. imports of IOPs were 106,000 t valued at $127 million in 2009 compared with 155,000 t valued at $164 million in 2008 (tables 1, 4). By tonnage, the leading sources of natural IOP imports were Spain with 41% of the tonnage and Cyprus with 36% of the tonnage. The leading sources of synthetic IOP imports were China with 46% of the tonnage; Germany, 28%; Brazil, 8%; and Italy, 7%. Imports decreased significantly because of the large decline in construction activity in the United States in 2009 (table 5).

World Review

Sixteen countries reported production of natural IOP in 2009 (table 6). Production increased in India, decreased in Germany and Turkey, and remained unchanged in most other countries. China and several eastern European countries are not included in table 6 because production data were not available. Production in Germany shown in table 6 included synthetic IOP.

China.—LANXESS began construction of a new plant to manufacture black iron oxide pigments in Jinshan, Shanghai Province. The plant was to have a capacity of 10,000 metric tons per year and was expected to be operational in late 2010. LANXESS also began making modifications to increase efficiency and reduce emissions at its adjacent yellow iron oxide pigment plant. The company planned to reduce emissions by at least 15% by 2011. Both plants serve Asian markets (LANXESS AG, 2009a).

Italy.—Rockwood Pigments NA, Inc. commissioned a high-purity synthetic iron oxide pigment plant in Turin. The plant, operated by Rockwood Italia S.p.A., was certified under the Good Manufacturing Practice regulations issued by the Food and Drug Administration in the United States. The certification ensured Rockwood's pharmaceutical customers that the iron oxide pigments used for such applications as coloring and marking pharmaceuticals were manufactured according to the pharmaceutical industry rules (Rockwood Pigments NA, Inc., 2009).

United Kingdom.—Prince Mineral Holding Corp. purchased Castle Colours Ltd., a leading supplier of colorants for the

European brick and tile industry. Prince Mineral Holding, through its subsidiary Prince Minerals, Inc., already was a global supplier of iron oxide pigments. The purchase of Castle Colours, however, gives Prince Minerals even greater access to European ceramic brick markets (O'Driscoll, 2009; Prince Minerals, Inc., undated).

Outlook

IOP mining declined worldwide in 2009 because of the negative effect of the global economic recession. The recession resulted in decreased construction activity and lower demand for IOPs for coloring concrete and paint, the two major markets for IOPs.

One major global IOP producer, Rockwood Pigments, indicated that its sales declined in 2008 and 2009 in North America and Europe (Rockwood Holdings, Inc., 2010, p. 40). LANXESS, a leading world producer of synthetic IOP, indicated that sales of its pigment products declined in 2009, although price increases partially offset the decline in volume sales (LANXESS AG, 2010, p. 75). Despite the travails of 2008 and 2009, the International Monetary Fund (IMF) predicted a slightly better economy in 2010. Economic stimulus packages, low interest rates, and low inflation were helping to stimulate a global recovery. IMF expected global output to increase by 4% in 2010. The fastest growth was expected in countries with emerging and developing economies. In particular, the IMF predicted 4% to 10% growth in Asian markets. In Europe and North America, however, the IMF predicted growth of 1% to 3% (International Monetary Fund, 2010). Improvement in the global economy may result in increased activity in IOP markets. In Europe and North America, IOP markets may increase 2% or 3% while those in Asia may increase 4% to 5%.

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TABLE 1

SALIENT U.S. IRON OXIDE PIGMENTS STATISTICS[1]

		2005	2006	2007	2008	2009
Crude pigments sold or used:[2]						
Quantity	metric tons	W	W	W	W	W
Value	thousands	W	W	W	W	W
Finished pigments sold:[e, 3]						
Quantity	metric tons	90,300 r	70,300	88,100	83,300 r	50,800
Value	thousands	$93,400	$69,300	$122,000	$116,000 r	$74,000
Exports:[4]						
Quantity	metric tons	2,220	3,100	5,410	4,740	5,640
Value	thousands	$6,170	$8,090	$15,900	$12,100	$15,500
Imports for consumption:[3]						
Quantity	metric tons	193,000	199,000	178,000	155,000	106,000
Value	thousands	$140,000	$159,000	$154,000	$164,000	$127,000

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Mined.

[3] Natural (mined) and synthetic.

[4] Pigment grade.

TABLE 2

PRODUCERS OF IRON OXIDE PIGMENTS AND REGENERATED IRON OXIDES IN THE UNITED STATES IN 2009

Producers	Plant location
Crude pigments:	
Alabama Pigments Co.	Green Pond, AL.
Hoover Color Corp.	Hiwassee, VA.
New Riverside Ochre Co., Inc.	Cartersville, GA.
Finished pigments:	
Alabama Pigments Co.	Green Pond, AL.
Dynamic Color Solutions, Inc.	Milwaukee, WI.
Hoover Color Corp.	Hiwassee, VA.
LANXESS Corp.	New Martinsville, WV.
New Riverside Ochre Co., Inc.	Cartersville, GA.
Prince Minerals, Inc.	Quincy, IL; and Bowmanstown, PA.
Rockwood Pigments NA, Inc.	Beltsville, MD; Easton, PA; and St. Louis, MO.
Regenerator iron oxides:	
ArcelorMittal Weirton Inc.	Weirton, WV.
Bailey-PVS Oxides, L.L.C.	Decatur, AL; Fairfield, AL; and Delta, OH.
International Steel Services, Inc.	Allenport, PA.

TABLE 3
U.S. EXPORTS OF IRON OXIDES AND HYDROXIDES, BY COUNTRY[1]

	Pigment grade				Other grade			
	2008		2009		2008		2009	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Australia	232	$573	166	$512	158	$485	5	$39
Belgium	1,760	4,820	700	3,360	36	165	54	389
Brazil	230	1,250	235	1,210	161	293	105	222
Canada	144	157	61	81	11,500	17,100	6,800	11,800
China	176	453	2,280	2,360	27,100	5,390	190	436
Germany	--	--	54	140	391	1,070	79	547
Hong Kong	176	380	165	517	12	15	44	131
India	38	102	30	154	53	80	21	74
Italy	96	236	42	144	861	726	520	441
Japan	54	142	60	82	40	32	19	161
Korea, Republic of	353	1,070	662	3,910	87	542	138	437
Mexico	595	474	472	420	3,880	1,780	2,130	1,310
Taiwan	33	106	44	217	108	464	23	193
Thailand	3	15	20	116	820	256	27	80
United Kingdom	352	1,150	112	493	292	1,040	285	745
Other	495 r	1,210 r	534	1,760	1,350 r	2,330 r	889	1,450
Total	4,740	12,100	5,640	15,500	46,900	31,800	11,300	18,500

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF SELECTED IRON OXIDE AND HYDROXIDE PIGMENTS, BY TYPE[1]

	2008		2009		
Type	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Principal sources, 2009 (metric tons)
Natural:					
Earth colors[3]	3,130	$1,580	862	$440	Cyprus, 686; Spain, 174.
Micaceous	1,570	1,060	1,040	633	Spain, 612; Austria, 208; France, 162.
Total	4,700	2,640	1,900	1,070	
Synthetic:					
Black	36,200	40,800	25,100	36,600	Germany, 11,600; China, 5,800; Italy, 3,430; Japan, 3,380.
Red	58,000	58,300	40,700	41,200	China, 24,700; Germany, 9,880; Belgium, 2,250; Italy, 1,350.
Yellow	53,700	57,200	37,500	45,300	China, 17,600; Germany, 8,150; Brazil, 7,920; Italy, 2,710.
Other[4]	2,770	4,790	1,250	2,770	Canada, 641; China, 377; France, 105.
Total	151,000	161,000	105,000	126,000	
Grand total	155,000	164,000	106,000	127,000	

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

[3] Includes those earth colors not elsewhere specified or included.

[4] Includes synthetic brown oxides, transparent oxides, and magnetic and precursor oxides.

Source: U.S. Census Bureau and the U.S. International Trade Commission.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF IRON OXIDE AND IRON HYDROXIDE PIGMENTS, BY COUNTRY[1]

	Natural				Synthetic			
	2008		2009		2008		2009	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Austria	95	$117	208	$247	--	--	3	$52
Belgium	--	--	--	--	2,010	$1,470	2,340	1,640
Brazil	10	29	--	--	8,010	7,850	7,970	8,810
Canada	--	--	--	--	2,910	4,550	1,520	3,260
China	--	--	20	14	85,400	79,000	48,400	44,300
Colombia	--	--	--	--	1,670	2,620	1,400	1,880
Cyprus	2,870	1,350	686	332	--	--	--	--
France	446	320	163	127	322	1,130	148	520
Germany	50	69	37	42	37,300	44,600	29,600	38,100
Italy	2	8	(3)	2	6,490	8,240	7,510	13,000
Japan	9	38	--	--	3,340	8,720	3,870	12,600
Spain	1,180	694	786	285	264	249	241	192
Sweden	--	--	--	--	1,370	281	356	76
Other	44 [r]	19 [r]	2	24	1,620 [r]	2,460 [r]	1,100	1,550
Total	4,700	2,640	1,900	1,070	151,000	161,000	105,000	126,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

[3] Less than ½ unit.

Source: U.S. Census Bureau and the U.S. International Trade Commission.

TABLE 6
NATURAL IRON OXIDE PIGMENTS: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009
Austria	5,000 [r]	5,000 [r]	5,000 [r]	5,000 [r]	5,000
Brazil	2,000	2,000	2,000	2,000	2,000
Cyprus, umber	12,000	12,000	12,000	12,000	12,000
France	2,500	2,791 [4]	2,800	2,800	2,800
Germany[5]	231,585 [4]	242,264 [4]	240,310 [4]	251,412 [4]	209,172 [4]
Guatemala	-- [r]	-- [r]	--	--	--
Honduras	17,000	17,000	17,000	17,000	17,000
India, ocher	360,000	370,000 [r]	375,000 [r]	380,000 [r]	385,000
Iran	2,500	2,600	2,600	2,600	2,600
Italy	500	500	500	500	500
Lithuania	--	4	4	4	4
Pakistan, ocher	5,500	5,500	6,000	6,000	6,000
Paraguay, ocher	250	250	250	250	250
South Africa	510 [4]	590 [4]	232 [4]	39 [4]	--
Spain, ocher	140,000	140,000	140,000	140,000	140,000
Turkey[6]	280,000	206,000	260,000	220,000	100,000
United Kingdom, iron oxides and hydroxides[7]	12,000	8,913 [4]	8,000	8,000	8,000
United States	W	W	W	W	W

[r] Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Estimated data are rounded to no more than three significant digits.

[2] Table includes data available through July 26, 2010.

[3] In addition to the countries listed, a number of others undoubtedly produce iron oxide pigments, but output is not reported and no basis is available for formulating estimates of output levels. Such countries include Azerbaijan, China, Kazakhstan, Russia, and Ukraine. Unreported output is probably substantial.

[4] Reported figure.

[5] Production includes natural and synthetic iron oxide pigments.

[6] Production includes micaceous iron oxide pigment and earth paints.

KYANITE AND RELATED MATERIALS

By Jason Christopher Willett

The United States continued to be the world's leading producer of kyanite and mullite (calcined kyanite), with production of 71,000 metric tons (t) in 2009 (table 3). Production of synthetic mullite in the United States was an estimated 40,000 t. Andalusite was mined and marketed as part of a mineral mixture at one U.S. operation, but data were withheld to avoid disclosing company proprietary data. There was no reported U.S. production of sillimanite. Refractory products continued to be a major end use for kyanite and related materials.

This report includes information on andalusite, kyanite, and sillimanite (all of which have the formula Al_2SiO_5), and mullite and synthetic mullite ($3Al_2O_3{\bullet}2SiO_2$). Mullite, a refractory (heat-resistant) material, can be made by calcining kyanite at high temperature (for example, above 1,450 °C). By contrast, synthetic mullite refers to mullite made by calcining at high temperature certain mixtures of alumina- and silica-containing minerals and materials, including bauxite and kaolin.

Production

Kyanite Mining Corp. (KMC), the sole U.S. producer of kyanite and kyanite-derived mullite, operated two open pit mines in Buckingham County, VA, and beneficiated the ore into a marketable kyanite concentrate. The company also had two kilns at its Dillwyn, VA, facility for the production of mullite from kyanite. Reported U.S. production data collected by the U.S. Geological Survey (USGS) were withheld to avoid disclosing company proprietary data. Production was estimated through employment data provided by the Mine Safety and Health Administration (MSHA) and nongovernment estimates from previous years. In 2009, 71,000 t of kyanite was reported produced in the United States, a decrease of about 27% compared with the reported production of 97,200 t in 2008 (Lassetter, 2009, 2010). The estimated value of the kyanite produced in the United States in 2009 was $20 million, a decrease of 21% compared with $26 million in 2008. The average unit value for raw and worked kyanite increased by 8% compared with the average unit price for 2008. KMC's mullite product contained about 80% mullite (Kyanite Mining Corp., 2006). Synthetic mullite, made from calcined bauxitic kaolin and sold by C-E Minerals, Inc., contained up to 87% mullite and was produced near Americus, GA (C-E Minerals, 2010). Based on nongovernment estimates from previous years, estimated U.S. production of synthetic mullite was about 40,000 t in 2009; the estimated value for the material was about $10 million.

Piedmont Minerals Co., Inc. in Hillsborough, NC, mined a deposit containing andalusite combined with pyrophyllite and sericite. The company sold products containing blends of the three minerals to producers of ceramics and refractories.

Consumption

Kyanite increases in volume by 16% to 18% when calcined to mullite and can be used in its raw concentrate form in a refractory mixture to offset the shrinkage on firing of other components, especially clays. Andalusite expands irreversibly by about 4% to 6% when calcined, and can be used directly in refractories in its raw state (Dickson, 2006; Lassetter, 2007). In other refractory applications, kyanite concentrate is calcined to mullite before being added to refractory mixes if the volume increase of the kyanite is not required in the mix. Mullite is resistant to abrasion and penetration of deleterious dusts, gases, and slags. It also has beneficial creep resistance, which limits physical deformation under load at high temperatures (Roskill Information Services Ltd., 1990, p. 56, 63).

Examples of refractories that contain andalusite, kyanite, or mullite include insulating brick, firebrick, kiln furniture, refractory shapes, and monolithic refractories (made of a single piece or as a continuous structure), including castables (refractory concrete), gunning mixes, mortars, plastics, and ramming mixes.

Monolithic refractories are supplied in unfired and unshaped form, in contrast to prefired and preshaped brick products. They may be gunned, hand packed, moulded, poured, pumped, rammed, or vibrated into place (Moore, 2004).

Iron and steel production continued to be the leading user of refractories. World and U.S. crude steel output decreased for the second consecutive year, by about 8% and 36%, respectively, in 2009 from that of 2008. The leading steel-producing countries and their share of 2009 steel output of 1.22 billion metric tons were China, 47%; Japan, 7%; Russia, 5%; the United States, 5%; India, 5%; and the Republic of Korea, 4%. These countries accounted for 879 million metric tons of steel production in 2009, a slight decrease in production from the same countries compared with that of 2008 (World Steel Association, 2010a). Other refractories users were in the nonferrous metal and glass industries (Sweet, Dixon, and Snoddy, 2006). Other end uses of kyanite and related materials include brake shoes and pads, electrical porcelain, foundry use, precision casting molds, sanitaryware, and other products (Kyanite Mining Corp., 2006).

Foreign Trade

An estimated one-third of U.S. kyanite and mullite output was exported. Most of the material imported into the United States in 2009 was from France and South Africa and was presumed to be andalusite (table 2). In 2009, imports of andalusite decreased by 12% compared with those of 2008. No U.S. imports of kyanite or sillimanite were reported in 2009.

World Review

South Africa continued to be the leading producing country of andalusite, with an estimated 210,000 t produced in 2009 (table 3). France produced an estimated 65,000 t of andalusite. Although China appeared to be a producer of kyanite and related minerals (Dickson, 2006), detailed production data have been unavailible since 2003 (O'Driscoll, 2010). India was the dominant producer of sillimanite, with an estimated

16,500 t of sillimanite and 7,700 t of kyanite in 2009. Countries that are thought to be producers of synthetic mullite [sintered mullite and (or) fused mullite] include Brazil, China, Germany, Hungary, and Japan (Taylor, 2005).

For refractories markets in China, India, and Japan, the steel industry used 70% to 75% of the tonnage. Two of the world's largest refractories companies reported that the steel industry accounted for about 60% of their annual sales worldwide (Semler, 2007a).

Outlook

Natural raw materials, such as andalusite and kyanite, continue to be important in refractory manufacturing. For even more durable refractories, technology advances included increased usage of such processed raw materials as synthetic mullite. As the technology for manufacturing refractories continues to improve, the use of synthetic raw materials in the production of refractories could continue to grow. Other general material use trends could include the increased development and use of monolithic products and a gradual increase in the use of recycled refractory materials (Semler, 2007b).

China and Japan have been major locations for the production and consumption of refractories. Opportunities for market expansion could exist in other areas, such as the Commonwealth of Independent States, Eastern Europe, the Middle East, and Southeast Asia (Semler, 2007b).

For Canada, Mexico, and the United States, steel consumption was projected to increase in 2010 because of stock rebuilding coupled with a recovery in the U.S. economy. China's apparent steel use was projected to increase by 7% in 2010, and India may experience a 14% increase. World steel consumption was forecast to increase by 5% in 2010 compared with that of 2009 (World Steel Association, 2010b).

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TABLE 1
PRICE OF KYANITE AND RELATED MATERIALS IN 2009

(Dollars per metric ton)

	Price
Kyanite, USA, ex-works, raw, 54% to 60% alumina	233–332
Kyanite, USA, ex-works, calcined (mullite), 54% to 60% alumina, 22-ton lots	387–456

Source: Industrial Minerals, December 2009, p. 69.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF ANDALUSITE, KYANITE, AND SILLIMANITE[1, 2, 3]

Year	Quantity (metric tons)	Value[4] (thousands)
2008	5,580	$1,930
2009	4,880	2,060

[1] Most material is andalusite from South Africa. No kyanite or sillimanite imports were reported.

[2] Harmonized Tariff Schedule of the United States code 2508.50.0000.

[3] Data are rounded to no more than three significant digits.

[4] Customs value.

Source: U.S. Census Bureau.

TABLE 3
KYANITE AND RELATED MATERIALS: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country and commodity[3]	2005	2006	2007	2008	2009
Australia:					
Kyanite	1,000	1,000	1,000	1,000	1,000
Sillimanite[4]	300	300	300	300	300
Brazil, kyanite, marketable	600	600	600	600	600
China, unspecified	3,400	3,400	3,500	4,000	4,000
France, andalusite	65,000	65,000	65,000	65,000	65,000
India:					
Kyanite	6,800	7,000	7,300	7,500	7,700
Sillimanite	15,000	15,000	15,200	16,000	16,500
South Africa, andalusite	228,265 [5]	221,209 [5]	264,645 [5]	216,667 [r, 5]	210,000
United States:					
Kyanite	100,000 [r, 6]	100,000 [r, 6]	118,000 [7]	97,200 [r, 8]	71,000 [9]
Mullite, synthetic	40,000	40,000	40,000	40,000	40,000

[r] Revised.

[1] U.S. and estimated data are rounded to no more than three significant digits.

[2] Owing to incomplete reporting, this table has not been totaled. Table includes data available through March 26, 2010.

[3] In addition to the countries listed, a number of other nations produce kyanite and related materials, but output is not reported quantitatively, and no reliable basis is available for estimation of output levels.

[4] In addition, about 7,000 metric tons of sillimanite clay (also called kaolinized sillimanite) that contains 40% to 48% Al_2O_3 is produced.

[5] Reported figure.

[6] Estimated based on the part 50 report published by the Mine Safety and Health Administration. (Accessed March 9, 2009, via http://www.msha.gov/stats/part50/p50y2k/aetable.htm).

[7] Source: Lassetter, W.L., Jr., 2008, Kyanite, andalusite, sillimanite and mullite: Mining Engineering, v. 60, no. 6, June, p. 44–45.

[8] Source: Lassetter, W.L., Jr., 2009, Sillimanite minerals: Mining Engineering, v. 61, no. 6, June, p. 68–69.

[9] Source: Lassetter, W.L., Jr., 2010, Sillimanite minerals: Mining Engineering, v. 62, no. 6, June, p. 74–76.

LEAD

By David E. Guberman

Domestic survey data and tables were prepared by Elsie D. Isaac, statistical assistant, and the world production tables were prepared by Glenn J. Wallace, international data coordinator.

In 2009, domestic lead mine production of recoverable lead was 395,000 metric tons (t), a slight decrease compared with that of 2008. Alaska and Missouri were the dominant producing States with a 94% share of total domestic mine production. Other States with appreciable lead mine production were Idaho, Montana, and Washington. Lead was produced at 11 U.S. mines that employed about 1,200 people. The value of domestic mine production was $757 million, a 29% decrease from the value of domestic mine production in 2008, owing to a decline in the average price of lead in 2009. Primary lead metal was produced at a smelter-refinery in Missouri.

Secondary lead, derived principally from scrapped lead-acid batteries, accounted for 91% of refined lead production in the United States in 2009. Nearly all the secondary lead was produced by 7 companies operating 15 smelters. Domestic secondary lead production decreased by 3% from that of 2008.

Lead was consumed in about 76 U.S. plants to manufacture such products as ammunition; building-construction materials; covering for power and communication cable; lead oxides in ceramics, chemicals, glass, and pigments; lead sheet; solders for construction, electrical-electronic components and accessories, metal containers, and motor vehicles; and storage batteries.

World mine production of lead increased slightly, to 3.86 million metric tons (Mt) in 2009. The United States accounted for about 11% of global lead mine production and was ranked third in the world. China and Australia were the two leading world lead producers in 2009 accounting for 41% and 15%, respectively, of global lead mine production. World production of refined lead (primary and secondary) increased slightly, to 8.82 Mt in 2009 from 8.70 Mt in 2008. The United States was the second leading producer of refined lead in the world and accounted for 14% of global refined lead production. China produced about 42% of global refined lead production and was the leading producer of refined lead in 2009.

According to the International Lead and Zinc Study Group (2010c, p. 8–9) (ILZSG), consumption of refined lead decreased slightly to 8.63 Mt in 2009 from 8.65 Mt in 2008, the first annual decline in global lead consumption since 2001. The leading refined-lead-consuming countries in 2009 were China, 45%; the United States, 16%; Germany, 4%; and the Republic of Korea, 3%. ILZSG data indicated that there was a global refined lead supply surplus of about 100,000 t by yearend 2009.

Lead-acid batteries, including starting-lighting-ignition (SLI) and industrial types, continued to be the dominant use of lead, accounting for about 89% of reported lead consumption. SLI battery shipments in North America totaled 109.5 million units in 2009, down by 6% from that of 2008. This total included original equipment (OE) and replacement automotive-type batteries.

Following significant declines that took place in the second half of 2008, lead prices steadily increased during 2009. In 2009, the average London Metal Exchange Ltd. (LME) cash price was $0.78 per pound, a decline of 18% from that of 2008, and the North American Producer price declined by about 28% from that of 2008, to $0.87 per pound.

Legislation and Government Programs

Effective February 10, section 101 of the Consumer Product Safety Improvement Act set new limits on the allowable lead content in any product intended primarily for use by children. In general, a children's product that contained more than 600 parts per million (ppm) of lead in any accessible part was to be treated as a hazardous substance. The sale of such products would be banned in the United States and would potentially result in civil and criminal liability. In August 2009, the allowable lead limits in children's products were to drop to 300 ppm, and the limits were to be reduced again in 2011 to the lowest lead level determined to be technologically feasible at the time (U.S. Consumer Product Safety Commission, 2009).

In August, the U.S. Environmental Protection Agency (EPA) announced a series of steps intended to prevent lead poisoning in children. The steps included additional proposed requirements to protect children from lead-based paint, a new effort to ban the manufacture of lead wheel weights, and a lead poisoning prevention video contest. The EPA planned to begin the process to expand coverage and strengthen the requirements of the 2008 Renovation, Repair, and Repainting rule, which was intended to reduce exposures to lead-based paint hazards for young children. The new expanded rule proposed to eliminate a provision that exempted some types of housing from the requirement that contractors are trained, certified, and use lead-safe work practices when renovating, repairing, or painting a pre-1978 home. The EPA expected to finalize this rule by April 2010. The EPA also planned to pursue a ban on the manufacture and distribution of lead wheel weights in response to a 2009 petition from multiple environmental and public health organizations (U.S. Environmental Protection Agency, 2009a).

In December, the EPA strengthened regulations that govern the shipment of hazardous waste from the United States to other countries for recycling. The new measures were meant to increase oversight of existing regulations covered by the Resource Conservation and Recovery Act (RCRA). RCRA gave the EPA the authority to control the generation, transportation, treatment, storage, and disposal of hazardous waste. The new, strengthened regulations were created to insure that hazardous waste (inclusive of lead-acid batteries) could only be exported from the United States to those countries that had the capabilities to recycle those materials in an environmentally sound manner. The new measures stipulated that shippers of used lead-acid batteries would be required to provide export notification to and receive written consent from destination countries prior to exporting the materials for reclamation (U.S. Environmental Protection Agency, 2009b).

Production

Mine.—In 2009, domestic mine production of recoverable lead was 395,000 t, a slight decline compared with that of 2008. Alaska and Missouri contributed the major share of the U.S. mine output of lead. Lead mine production also was reported in Idaho, Montana, and Washington. The lead-producing mines in Montana and Washington were closed during the first quarter of 2009. Domestic mine production data were collected by the U.S. Geological Survey (USGS) from a precious-metal and base-metal voluntary survey on lode-mine production (tables 1–4).

Teck Alaska Inc. (a wholly owned subsidiary of Teck Resources Ltd., Vancouver, British Columbia, Canada) operated the Red Dog zinc-lead mine in northwestern Alaska under a royalty agreement with NANA Regional Corp., the sole owner of the property. NANA is a corporation organized under the provisions of the Alaska Native Claims Settlement Act. During 2009, Teck established a new annual record for contained metal production at Red Dog owing to increased mill operating rates and online time. Teck Alaska spent $6 million to add 14 new employees and consultants that worked exclusively to improve mine productivity, which resulted in multiple process improvements in 2009. Production of lead in concentrate at Red Dog in 2009 increased by about 7% to 131,500 t compared with 122,600 t of lead in concentrate in 2008. Red Dog's shipping season began June 30 and ended on October 18; 220,000 t of lead concentrate was shipped in 2009. The company expected to produce 95,000 t of lead in concentrate at Red Dog in 2010, a decrease from 2009 production, owing to the mining of lower ore grades at the bottom of the main ore pit. At current production rates, the main pit was expected to be exhausted by the end of the first quarter of 2011. To ensure that production at Red Dog continues beyond 2011, Teck planned to begin mining at the adjacent Aqqaluk deposit in 2010. Beginning in 2011, the Aqqaluk deposit would become the main ore supply for the next 20 years. As of yearend 2009, Teck was awaiting the necessary permits from the EPA and the State of Alaska to commence prestripping and initial production at the Aqqaluk site (Teck Resources Ltd., 2010a, p. 27; 2010b, p. 44–45).

Teck's Pend Oreille zinc-lead mine in northeastern Washington, which produced 5,700 t of lead in concentrate in 2008, was placed on care-and-maintenance status in February 2009 owing to reduced metal demand and weakened zinc prices. A core group of employees remained at Pend Oreille after the shutdown to facilitate a possible restart in the future, while approximately 165 other employees were laid off and given severance packages and other benefits. Pend Oreille produced 900 t of lead in concentrate in 2009 before mining operations ceased. Proven and probable ore reserves at Pend Oreille, as of December 31, 2009, reportedly were estimated to be almost 1.9 Mt grading 6.1% zinc and 1.2% lead (Teck Cominco Ltd., 2010a, p. 27; 2010b, p. 45).

In January 2009, Doe Run Resources Corp. (St. Louis, MO) announced a 17% reduction in planned ore production at its southeastern Missouri lead mines in 2009. This adjustment to the original 2009 production plan was made in response to declines in the market price of lead during the second half of 2008. Based on the updated plan, Doe Run expected to produce about 4.5 Mt of ore in 2009. The company also reduced the workforce employed at its mills, mines, and smelters by 10%. The reduction in mine production came 3 months after Doe Run decided to temporarily take one of two blast furnaces offline and reduce production of primary refined lead at its smelter in Herculaneum, MO (Riley, 2009).

In early December 2008, the ore from the Montana Tunnels open pit operation near Helena, MT, was exhausted and the mine ceased operation. Apollo Gold Corp. (Greenwood Village, CO) was operator and a joint-owner of the Montana Tunnels with Elkhorn Tunnels LLC (Denver, CO). During the 4-month period that ended April 30, 2009, the mill processed 1.30 Mt of ore, which had been stockpiled when mining operations stopped at yearend 2008. Payable production of lead in 2009 was 1,510 t, 79% less than the 7,060 t of payable lead produced in 2008. During the third quarter of 2009, Apollo entered into an agreement to sell its 50% interest in the Montana Tunnels to Elkhorn, giving it 100% ownership of the mine. Elkhorn's immediate plans for the mining operations were unclear, but the potential for future mining did exist based on permits that Apollo had previously received that allowed for the expansion of the current pit (Apollo Gold Corp., 2010, p. 12, 60).

U.S. Silver Corp. (Toronto, Ontario, Canada) produced silver-lead ore at the Galena Mine located in the Coeur d'Alene mining district in Shoshone County, ID. In 2009, the company produced 2,920 t of lead in concentrate, a 54% increase from the 1,900 t produced in 2008. The production increases were attributed to improved operational efficiencies and mining techniques and continued progress made on rehabilitation work that the company has been performing since 2007. The company was working to repair and to reopen a key mine shaft that had been closed since 2000 owing to partial collapses and had limited the company's ability to reach some levels of the underground mine. U.S. Silver expected to have access to levels of the mine containing higher grade ore upon completion of the shaft rehabilitation work in 2010 (U.S. Silver Corp., 2009, p. 1, 21).

Primary.—Doe Run produced primary lead at a smelter-refinery facility in Herculaneum, MO. Concentrates for the smelter-refinery were provided mainly from four Doe Run mills that were supplied with ore mined from six production shafts along the Viburnum Trend in southeastern Missouri. In 2009, domestic primary lead metal production was 103,000 t, a 23% decrease compared with that of 2008 owing to the closure of one of two furnaces at the smelter. In October 2008, Doe Run had announced that it had planned to temporarily close one of two blast furnaces at its primary lead smelter owing to the decline in lead prices and unfavorable market conditions. The company, which had successfully operated the smelter with a single furnace doing the bulk of the work at times, expected to restart the second furnace when the market recovered (American Metal Market, 2008).

Secondary.—Domestic secondary production of refined lead decreased by about 3% in 2009 from that of 2008. Secondary lead accounted for 91% of domestic lead refinery production compared with 89% in 2008. Lead-acid batteries continued to be the dominant source of recoverable lead scrap, accounting for 94% of all lead produced from secondary sources. The domestic secondary statistics were derived by the USGS from a combined secondary producer and consumer survey that included data from monthly and annual surveys. All of the 13 companies producing secondary lead, exclusive of that produced from copper-based scrap, were surveyed; 11 responded, representing about 99% of the total production of secondary lead. Of the total lead recycled in 2009, the majority was produced by 7 companies operating 15 plants in Alabama, California, Florida, Indiana, Louisiana, Minnesota, Missouri, New York, Pennsylvania, Tennessee, and Texas. Production and consumption for the nonrespondents were estimated by using prior-year levels as a basis (tables 1, 4–8).

Exide Technologies (Milton, GA) temporarily closed its secondary lead smelter in Baton Rouge, LA, in the second quarter of 2009 owing to the downturn in the U.S. economy and the lead-acid battery industry. The plant had been operating at about one-half of its production capacity of 60,000 metric tons per year (t/yr) of refined lead. Shutdown procedures began in April 2009, when the plant was scheduled to cease accepting used lead-acid batteries for recycling. Following the closure of the smelter, Exide expected that its Frisco, TX, secondary lead smelter would process some of the material that previously had been processed at Baton Rouge (Ryan's Notes, 2009).

EnviroFocus Technologies, LLC (a wholly owned subsidiary of Gopher Resource Corp., Eagan, MN) planned to spend $117 million to expand production capacity at its secondary lead smelter in Tampa, FL, by nearly 400%. When the project is completed by yearend 2011, the smelter would have the capacity to produce about 118,000 t/yr of refined lead, primarily from a feedstock of used lead-acid batteries. EnviroFocus planned to increase the number of full-time employees at the plant to 215 to support the added capacity (Schaffer, 2009a).

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Consumption

Reported U.S. consumption of refined lead decreased by about 11% in 2009. Significant decreases were reported in the casting metals, lead-acid storage batteries, and sheet lead end-use sectors. Consumption of lead in SLI and industrial type lead-acid storage batteries represented about 89% of the total reported consumption of lead (tables 5–8). Demand for lead is heavily reliant on the lead-acid battery industry and in turn the automotive sector. The Battery Council International (BCI) reported that North American shipments of SLI automotive batteries in 2009 totaled 109.5 million units, a 6% decrease from those in 2008. This was the second consecutive year that SLI automotive battery shipments declined on a year-by-year basis. Shipments of replacement SLI batteries in 2009 totaled 98.8 million units, slightly less than those in 2008. Replacement batteries represented 90% of all North American battery shipments in 2009 compared with 85% in 2008. North American shipments of OE SLI batteries were 10.7 million units in 2009, a decline of 38% from those of 2008. The dropoff in shipments of OE batteries was attributed to the decline in new vehicle production during 2009 owing to the economic downturn that began in late 2008 and continued throughout 2009. Total domestic vehicle production in 2009 was about 5.6 million units, nearly 34% less than that in 2008. New vehicle registrations declined in 2009, while the average age of the vehicle fleet on the road in the United States increased to 10.2 years, the highest level in history. Maintenance requirements of the aging fleet kept the replacement battery market stable while demand for OE batteries plummeted. As economic conditions worsened in 2009, consumers began to delay preventative vehicle maintenance, such as exchanging older batteries for new units, opting instead to wait until batteries failed before replacing them (Battery Council International, 2010a, p. 3–8; CRU International Ltd., 2010, p. 129–130).

In 2009, the BCI Technical Subcommittee released the results of a study on the frequency rates of different types of failures commonly observed in lead-acid batteries. Failure mode data had been collected by the Technical Committee since 1962 and analyzed every 5 years since 1990. In the most recent report, 1,496 batteries from 10 regions in the United States were sampled between September and December 2009. Based on analysis of the data collected from the sample of failed lead-acid batteries, the BCI reached several conclusions about lead-acid batteries in North America. The group of lead-acid batteries in the sample lasted an average of 55 months before failing, increasing from an average age of 50 months during the last study and 40 months in the 1999–2000 study, indicating that materials, manufacturing process, and vehicle design improvements have extended the average life of lead-acid batteries. Batteries used in hotter southern climates did not last as long as those used in cooler northern climates, and newer lead-acid batteries were more resistant to heat compared with batteries from 10 years ago. Short circuits and plate/grid failures remained the most common types of lead-acid battery failures. The study also indicated that failure rates of serviceable batteries had remained constant at 15%. Separately in 2009, the BCI published a national lead-acid battery recycling rate study for 2004 to 2008 that indicated that the recycling rate of lead contained in lead-acid batteries in the United States was 96% (Battery Council International, 2010b).

sound manner. The new measures stipulated that shippers of used lead-acid batteries would be required to provide export notification to and receive written consent from destination countries prior to exporting the materials for reclamation (U.S. Environmental Protection Agency, 2009b).

Production

Mine.—In 2009, domestic mine production of recoverable lead was 395,000 t, a slight decline compared with that of 2008. Alaska and Missouri contributed the major share of the U.S. mine output of lead. Lead mine production also was reported in Idaho, Montana, and Washington. The lead-producing mines in Montana and Washington were closed during the first quarter of 2009. Domestic mine production data were collected by the U.S. Geological Survey (USGS) from a precious-metal and base-metal voluntary survey on lode-mine production (tables 1–4).

Teck Alaska Inc. (a wholly owned subsidiary of Teck Resources Ltd., Vancouver, British Columbia, Canada) operated the Red Dog zinc-lead mine in northwestern Alaska under a royalty agreement with NANA Regional Corp., the sole owner of the property. NANA is a corporation organized under the provisions of the Alaska Native Claims Settlement Act. During 2009, Teck established a new annual record for contained metal production at Red Dog owing to increased mill operating rates and online time. Teck Alaska spent $6 million to add 14 new employees and consultants that worked exclusively to improve mine productivity, which resulted in multiple process improvements in 2009. Production of lead in concentrate at Red Dog in 2009 increased by about 7% to 131,500 t compared with 122,600 t of lead in concentrate in 2008. Red Dog's shipping season began June 30 and ended on October 18; 220,000 t of lead concentrate was shipped in 2009. The company expected to produce 95,000 t of lead in concentrate at Red Dog in 2010, a decrease from 2009 production, owing to the mining of lower ore grades at the bottom of the main ore pit. At current production rates, the main pit was expected to be exhausted by the end of the first quarter of 2011. To ensure that production at Red Dog continues beyond 2011, Teck planned to begin mining at the adjacent Aqqaluk deposit in 2010. Beginning in 2011, the Aqqaluk deposit would become the main ore supply for the next 20 years. As of yearend 2009, Teck was awaiting the necessary permits from the EPA and the State of Alaska to commence prestripping and initial production at the Aqqaluk site (Teck Resources Ltd., 2010a, p. 27; 2010b, p. 44–45).

Teck's Pend Oreille zinc-lead mine in northeastern Washington, which produced 5,700 t of lead in concentrate in 2008, was placed on care-and-maintenance status in February 2009 owing to reduced metal demand and weakened zinc prices. A core group of employees remained at Pend Oreille after the shutdown to facilitate a possible restart in the future, while approximately 165 other employees were laid off and given severance packages and other benefits. Pend Oreille produced 900 t of lead in concentrate in 2009 before mining operations ceased. Proven and probable ore reserves at Pend Oreille, as of December 31, 2009, reportedly were estimated to be almost 1.9 Mt grading 6.1% zinc and 1.2% lead (Teck Cominco Ltd., 2010a, p. 27; 2010b, p. 45).

In January 2009, Doe Run Resources Corp. (St. Louis, MO) announced a 17% reduction in planned ore production at its southeastern Missouri lead mines in 2009. This adjustment to the original 2009 production plan was made in response to declines in the market price of lead during the second half of 2008. Based on the updated plan, Doe Run expected to produce about 4.5 Mt of ore in 2009. The company also reduced the workforce employed at its mills, mines, and smelters by 10%. The reduction in mine production came 3 months after Doe Run decided to temporarily take one of two blast furnaces offline and reduce production of primary refined lead at its smelter in Herculaneum, MO (Riley, 2009).

In early December 2008, the ore from the Montana Tunnels open pit operation near Helena, MT, was exhausted and the mine ceased operation. Apollo Gold Corp. (Greenwood Village, CO) was operator and a joint-owner of the Montana Tunnels with Elkhorn Tunnels LLC (Denver, CO). During the 4-month period that ended April 30, 2009, the mill processed 1.30 Mt of ore, which had been stockpiled when mining operations stopped at yearend 2008. Payable production of lead in 2009 was 1,510 t, 79% less than the 7,060 t of payable lead produced in 2008. During the third quarter of 2009, Apollo entered into an agreement to sell its 50% interest in the Montana Tunnels to Elkhorn, giving it 100% ownership of the mine. Elkhorn's immediate plans for the mining operations were unclear, but the potential for future mining did exist based on permits that Apollo had previously received that allowed for the expansion of the current pit (Apollo Gold Corp., 2010, p. 12, 60).

U.S. Silver Corp. (Toronto, Ontario, Canada) produced silver-lead ore at the Galena Mine located in the Coeur d'Alene mining district in Shoshone County, ID. In 2009, the company produced 2,920 t of lead in concentrate, a 54% increase from the 1,900 t produced in 2008. The production increases were attributed to improved operational efficiencies and mining techniques and continued progress made on rehabilitation work that the company has been performing since 2007. The company was working to repair and to reopen a key mine shaft that had been closed since 2000 owing to partial collapses and had limited the company's ability to reach some levels of the underground mine. U.S. Silver expected to have access to levels of the mine containing higher grade ore upon completion of the shaft rehabilitation work in 2010 (U.S. Silver Corp., 2009, p. 1, 21).

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In early August, the U.S. Department of Energy (DOE) announced that it was awarding $2.4 billion in grants to accelerate the manufacturing and deployment of the next generation of batteries and electric vehicles in the United States. The grants, funded by the American Recovery and Reinvestment Act of 2009, were allocated to 48 advanced battery and electric vehicle component development projects in more than 20 States. The battery-related awards were distributed to companies involved in many different battery technologies including lead-acid battery development. Exide was awarded $34.3 million to produce lead-acid batteries that incorporate advanced carbon technology for hybrid-electric vehicle (HEV) applications. Exide had previously entered into a memorandum of understanding with Axion Power International, Inc. (New Castle, PA), the developer of a patented lead-carbon battery technology called PbC, to develop and deploy new lead-acid batteries that use this technology. The company planned to use the DOE grant to fund development of both PbC and existing absorbed glass mat lead-acid battery technologies for HEV applications. Exide expected that the investment would enable production capacity to expand by about 1.5 million batteries and create 320 new jobs at manufacturing facilities in Georgia and Tennessee (Exide Technologies, 2009b).

Separately, East Penn Manufacturing Co., Inc. (Lyon Station, PA) received a $32.5 million grant from the DOE to expand production capabilities and to manufacture advanced lead-acid batteries for HEVs. East Penn was planning to use the funding to become a leading source of advanced valve-regulated lead-acid batteries and for further development of the UltraBattery. East Penn had previously entered into an agreement to become the North American producer and distributor of the UltraBattery, an integrated lead-acid battery and supercapacitor that is considered suitable for HEV applications (East Penn Manufacturing Co., Inc., 2009).

The BCI reported that the sales value of industrial-type lead-acid batteries in North America, decreased by about 25% in 2009 compared with those of 2008, and unit sales declined by 11% in 2009 compared with that of 2008. The declines were reported for stationary power and motive power lead-acid batteries. Overall, 2009 shipments of industrial-type lead-acid batteries were valued at about $1.28 billion compared with sales of $1.70 billion in 2008. Stationary power batteries accounted for 56% of all industrial-type battery sales, and the remaining 44% was motive power batteries. In 2009, shipments of motive power lead-acid batteries declined by 25% from those in 2008. The majority of the motive power batteries sold in 2009 were those used in industrial trucks such as forklifts and material handling equipment. Demand for replacement motive power batteries remained constant, but sales of OE motive power batteries declined owing to a decrease in sales of new industrial trucks in 2009 compared with those of 2008. In 2009, sales of stationary power type lead-acid batteries that were used in uninterruptible power systems (UPS) applications and telecommunications installations decreased from sales in 2008 owing to a decline in corporate spending (Cullen, 2010).

Metalico Inc. (Cranford, NJ) was a leading domestic producer of nonbattery lead-based products in 2009. Metalico's lead fabricating segment produced lead sheet, shot, strips, and various extruded products at four fabricating facilities. In 2009, sales of fabricated lead products were valued at $62.5 million, a 30% decline compared with lead fabrication sales in 2008. The decline was attributed to a reduction in the average sales price of fabricated lead products in 2009 compared with that of 2008 (Metalico Inc., 2010, p. 30, 35).

Prices

Lead prices increased throughout most of 2009 despite a surplus of refined lead in the global market and a downturn in the global economy that weakened demand for base metals. The LME average cash price for lead was $1,132 per metric ton in January 2009, but by yearend had increased by 106% to $2,328 per metric ton, the highest average monthly LME price for lead since April 2008. Significant price increases in 2009 were not necessarily supported by the physical lead market, which was considered to be in surplus for the entire year. Stocks of refined lead held in LME warehouses increased 225%, from 45,150 t in the beginning of January 2009 to 146,775 t by yearend 2009. The industrial sectors of many nations that typically consume significant quantities of lead slowed in 2009, with China being the most notable exception. The loss of refined lead capacity in China owing to temporary smelter shutdowns was another contributing factor to price increases during the second half of 2009. On an annual average basis, the LME cash and North American Producer prices in 2009 were down by $0.168 per pound (18%) and $0.335 per pound (28%) respectively, from the average prices of $0.948 per pound and $1.203 per pound, respectively, in 2008.

Foreign Trade

In 2009, imports of unwrought lead metal for consumption totaled 251,000 t, a 19% decrease from those of 2008. The leading source was Canada, accounting for 82% of unwrought lead metal imports. Imports from Mexico decreased by 29% to 41,000 t, and those from Peru were down by 91% to 991 t. Total domestic exports of unwrought lead increased by 14% to 77,600 t. Mexico was the leading destination for the unwrought lead exported in 2009, accounting for about 75% of all shipments. Domestic exports of lead in concentrate were 287,000 t, a 4% increase from those of the previous year. Lead in concentrate exports to China and the Republic of Korea increased, while exports to Canada, Japan, and Mexico declined (tables 10–12).

In 2009, the United States imported about 22 million SLI lead-acid batteries for consumption, essentially unchanged from those of 2008. Mexico was the leading provider of SLI batteries, accounting for 70% of the SLI batteries imported in 2009. SLI batteries were also imported from China, Germany, the Republic of Korea, Spain, and Taiwan. The United States exported about 7.30 million spent SLI lead-acid batteries in 2009, 10% fewer than those of 2008. The majority of those units (88%) were shipped to Mexico for recycling.

World Review

World mine production of lead increased slightly to 3.86 Mt in 2009. China was the leading producer accounting for about 41% of the world total, followed by Australia, with 15%; the

United States, 11%; Peru, 8%; and Mexico, 4% (table 13). In 2009, four lead mines in Mexico, Peru, Russia, and Spain opened, adding about 129,000 t/yr of new global lead mine production capacity. The most significant of the new mines in terms of added capacity was the Penasquito Mine in Mexico. Six mines with a combined lead concentrate production capacity of 57,000 t/yr closed, four temporarily and two permanently. The mine closures were in Australia, Ireland, Peru, and the United States. Among the major lead-mine-producing countries, decreases took place in Australia, Canada, and Peru while mine production increased in Bolivia, China, Mexico, and Russia. The global economic slowdown caused exploration expenditures for base-metals projects to decline in many regions in 2009 compared with those of 2008. Mining companies cited the decline in global commodity prices and reduced access to capital as reasons for scaling back exploration.

World production of refined lead (primary and secondary) increased slightly, to 8.82 Mt in 2009 from 8.70 Mt in 2008. China was the leading producer of refined lead, accounting for 42% of total world production, followed by the United States, with 14%; Germany, 4%; and Australia, Canada, Japan, the Republic of Korea, and the United Kingdom, 3% each (table 14). Secondary (recycled) lead has accounted for an increasing portion of the total global lead supply during the past 10 years. Secondary lead production represented about 53% of total refined lead production worldwide in 2009 compared with 47% in 1999. In 2009, two lead smelters opened in China and Thailand, adding about 99,000 t/yr of refined lead production capacity. Conversely, six smelters closed in China, Italy, Peru, Romania, Switzerland, and the United States, resulting in a loss of 377,000 t/yr of refined lead production capacity in 2009 (International Lead and Zinc Study Group, 2010d, p. 5–6).

According to ILZSG (2010c, p. 8–9), consumption of refined lead decreased slightly to 8.63 Mt in 2009 from 8.65 Mt in 2008, the first annual decline in global lead consumption since 2001. The leading refined-lead-consuming countries in 2009 were China, 45%; the United States, 16%; Germany, 4%; and the Republic of Korea, 3%. ILZSG data indicated that there was a global refined lead supply surplus of about 100,000 t by yearend 2009.

Australia.—Xstrata plc (Zug, Switzerland) received final approval from the Australian Minister for the Environment, Heritage, and the Arts, to proceed with an open pit development plan at its McArthur River zinc-lead mine in Australia's Northern Territory. Operations at the mine, which had been suspended in mid-December 2008 following a federal court ruling that invalidated a previous approval of the development plan, were restarted in late February 2009. Xstrata intended to convert the existing underground zinc-lead mine to an open pit operation in order to extend the life of the mine by about 25 years. The most accessible underground ore at the mine had been extracted, and further underground mining operations were no longer financially viable. The proposed development allowed Xstrata to mine identified reported reserves of 43 Mt of ore containing 11.9% zinc, 5.2% lead, and 53 grams per metric ton silver. Upon receiving final approval for the conversion, Xstrata expected that the construction process would last at least 2 years. Production capacity of zinc-lead-silver bulk concentrates at McArthur River was reported to be about 320,000 t/yr in 2008. Lead in concentrate production in 2009 was 37,100 t, a slight increase from that in 2008 (McArthur River Mining Pty. Ltd., 2009; Xstrata plc, 2009).

In mid-August, Magellan Metals Pty. Ltd. [a wholly owned subsidiary of Ivernia Inc., (Toronto)] announced that the Western Australian government had given final approval to a plan that allowed for the transport of sealed containers of lead concentrate from the Magellan lead mine in Western Australia to the Port of Fremantle. The plan required Magellan to fund independent auditing, inspection, and monitoring of every shipment from the mine to ensure that lead was not entering the environment along the transport route. Magellan also consulted with all 22 local government authorities along the transport route to develop an emergency response program in the event of a mishap. Mining operations at Magellan had been suspended in April 2007 owing to environmental concerns associated with the transport of lead concentrate from the mine. On September 29, Magellan announced that it had commenced exporting sealed shipments of lead concentrate from existing stockpiles at the mine. The initial shipment consisted of 450 t of lead concentrate that was bagged, loaded into sealed containers, and then transported by road and then rail to the port, where it was shipped to a smelter in China. This was the first in a series of shipments scheduled to continue until 21,000 t of stockpiled lead concentrate was depleted, which was expected to take about 6 months. In late 2009, Ivernia began maintenance and refurbishment projects that would allow concentrating and mining operations to restart at Magellan in early 2010. The primary source of the lead produced at Magellan is a near-surface cerrusite (lead carbonate) deposit. When operating at full capacity, the mine was capable of producing about 85,000 t/yr of lead concentrate (Ivernia Inc., 2009a, b).

Belgium.—In Belgium, Umicore s.a. (Brussels) announced that it had decided to close the lead sheet operation at its Overpelt facility, which had been operating in a declining market for some time. The European construction industry, which consumed lead sheet products for roofing, experienced a slowdown in activity that began in the fourth quarter of 2008 (Umicore s.a., 2009).

Bolivia.—Atlas Precious Metals Inc. was expecting to bring its primary lead-silver smelter in Karachipampa onstream in early 2010. Atlas was planning to begin production at the smelter upon receiving an environmental permit that would allow for the installation of a 500,000-t/yr sulfuric acid plant. When operating at full production, the plant would produce about 21,000 t/yr of primary refined lead, 196 t/yr of silver, and 30,000 t/yr of recovered byproducts such as bismuth crystals, indium, and zinc oxide (Metal Bulletin, 2009a).

Canada.—In 2009, lead concentrates were produced at two mines located in British Columbia and New Brunswick. There was a 31% decrease in mine production in 2009 compared with that of 2008 owing to the closure of several mines that had reopened when metal prices were elevated in 2006 and 2007. Primary refined lead metal was produced from domestic and foreign concentrates at two smelters located in New Brunswick and British Columbia. Secondary lead metal was produced from recycled lead (primarily lead-acid batteries) at four sites in Quebec, Ontario, and British Columbia. Total refined lead production in 2009 was essentially unchanged from that in 2008 (Natural Resources Canada, 2010, p. 1–29).

Xstrata's underground zinc-lead mine near Bathurst, New Brunswick, was the leading producer of lead in concentrate in Canada. The mine had production capacity to process 3.60 Mt of ore containing copper, lead, silver, and zinc on an annual basis. In 2009, Brunswick Mine produced 66,000 t of lead in concentrate, down by 6% from the 70,000 t produced in 2008. The operating status of the Brunswick mine was expected to change during the next 2 years owing to depletion of mineral resources at the site. The mine was slated to reach the end of its life and close in early 2010; however, Xstrata was focusing efforts on extending the life of the mine to yearend 2012 (Xstrata plc, 2010a, p. 95).

In late March, Acadian Mining Corp. (Halifax, Nova Scotia) placed its Scotia open pit, lead-zinc mine in Gays River, Nova Scotia, on care-and-maintenance status owing to the decline in zinc and lead prices in 2008. Between the second quarter of 2007 when operations at the Scotia Mine were restarted and fourth quarter 2008, the company produced about 8,540 t of lead in concentrate. Upon the mine closure, the company planned to primarily engage in the exploration, acquisition, and development of gold, base metal, and barite properties on the Atlantic coast of Canada (Acadian Mining Corp., 2010, p. 4, 91).

Teck announced that 2009 refined lead production at its metallurgical complex at Trail was 72,600 t, a 15% decrease from that of 2008 owing to operational issues in the drossing plant, where the lead is purified. The drossing furnace separates copper and other impurities from lead bullion tapped from the Kivcet furnace before the lead is sent to the refinery. In the fourth quarter of 2009, Teck shut down the primary lead smelter for 20 days to perform maintenance work and repairs after loose bricks were discovered inside the furnace. By yearend 2009, the lead smelter had returned to full production. Teck expected to produce 80,000 t of refined lead at Trail in 2010 (American Metal Market, 2009; Teck Resources Ltd., 2010b, p. 44).

China.—China continued to be the leading global producer and consumer of lead in 2009. China was also the leading producer of lead-acid batteries in the world. Between 1999 and 2009, China's demand for lead contained in lead-acid batteries was generated by tremendous growth in the production of automobiles, electric bicycles (e-bikes), and motorcycles, increasing by 23%, 74%, and 8% respectively. The number of e-bikes in China had grown to an estimated 100 million by yearend 2009. Each e-bike needed at least one lead-acid battery per year, containing about 10 kilograms of lead, to operate, which translated to about 1 Mt of lead consumed for this use in 2009. Consumption of lead in China has increased by an average of 20% per year from 1999 to 2009 and was estimated to be about 3.86 Mt in 2009 (International Lead and Zinc Study Group, 2010a, p. 1–14).

Lead in concentrate production in 2009 was 1.60 Mt, a 7% increase from the 1.50 Mt produced in 2008. Mine ore production increased dramatically in the fourth quarter of 2009 from that early in the year, as mining companies attempted to meet their annual production goals. Guangxi, Henan, Hunan, and Sichuan Provinces had the greatest production increases in 2009 compared with production in 2008. China also imported about 884,000 t of lead in concentrate in 2009, 11% more than lead in concentrate imports in 2008.

Refined lead production in 2009 was 3.71 Mt, a 16% increase from the 3.20 Mt produced in 2008. Despite deteriorating market conditions during the global economic slowdown in 2009 and the Government's emphasis on phasing out smaller nonferrous metal-producing facilities, major producers continued with plans to increase and modernize lead refining capacity in China. In June, Luoyang Yongning Gold and Lead Smelting Co., Ltd. commissioned a new 80,000-t/yr primary lead smelter. Yuguang Gold and Lead Co. Ltd. planned to commission a new 80,000-t/yr lead smelter after the completion of trial production that began in October 2009. In July, Jianxi Copper launched construction of new smelters that were to have the capacity to produce 100,000 t/yr of lead and zinc by yearend 2011. In total, at least 11 lead-smelting projects were under construction and had the potential to add about 600,000 t/yr of refined lead capacity by yearend. Secondary production has become an increasingly significant part of the lead metal supply in China owing to the growing quantities of used lead-acid batteries generated by the automobile and e-bike markets. In 2009, secondary lead production accounted for 35% of total refined lead production in China, compared with 22% in 2005. Secondary lead production was expected to continue to increase and approach 50% of total refined lead output by 2015. In 2009, 157,000 t of refined lead was imported, 409% more than in 2008 (China Metal Market—Lead, Zinc & Tin, 2009a, p. 2; 2009b, p. 1–2; 2010, p. 8–13).

The National Development and Reform Commission released a 3-year plan to consolidate and improve the country's nonferrous metals industry in response to the deteriorating global financial situation. The Government intended to phase out 1.30 million metric tons per year of nonferrous metal production capacity by yearend. The reductions included 300,000 t/yr of copper, 600,000 t/yr of lead, and 400,000 t/yr of zinc smelting capacity. Plants that had been using outdated or obsolete production technologies were to be closed, and the Government encouraged mergers and restructuring in the industry to improve economies of scale. Ultimately, a handful of leading companies would produce the majority of the nonferrous metals in China, potentially creating a more stable production base (Mining Journal, 2009).

In the third quarter of 2009, China's Ministry of Environmental Protection demanded urgent measures to reduce heavy-metal poisoning in response to an increase in such incidents during the year. Multiple lead smelters and lead-acid battery producers were forced to cease operations during 2009 owing to the poisoning of populations living in close proximity to plants in Henan, Hunan, Shaanxi, and Yunnan Provinces. Thousands of children had elevated levels of lead in their blood as a result of pollution generated from lead smelters and battery plants. The most notable of the initial incidents involved elevated lead levels discovered in the blood of more than 600 children living near a lead and zinc smelter in Shaanxi Province in August 2009. The incident led to further investigation of lead smelters by the government and environmental officials and revealed similar problems in other locations. It was estimated that by fall of 2009, about 400,000 t to 500,000 t of refined lead capacity (9.5% of total capacity) in China had been idled or was under investigation and likely to be closed by authorities owing to environmental concerns. The abundance of smaller lead smelters in China made it more difficult for the government to monitor and regulate lead pollution. These plant closures were a driving force behind a midyear spike in LME lead prices, but they were not expected to have a long-term impact on Chinese refined lead supply. In September, the Ministry of Environmental Protection passed a plan for the comprehensive rectification of heavy-metal pollution, focusing on arsenic, cadmium, chromium, lead, and mercury pollution. Details of the plan were not disclosed in full, but initial action involved sending inspection teams out to major lead-producing provinces to conduct environmental checks. It was expected that during the next few years, federal and regional governments would continue to work towards phasing out older smelting capacity that was often linked to lead poisoning incidents in favor of more modern facilities that are better equipped to limit environmental emissions (Metal Bulletin, 2009b; Metal-Pages, 2009).

Guatemala.—In late May, Acumuladores Iberia S.A. (Guatemala City) secured a license from the Guatemalan Government to import used lead-acid batteries. Acumuladores Iberia operated a lead recycling plant in Guatemala City that processed about 120,000 used lead-acid batteries per year from domestic sources. With this new import license, the company would have the capacity to recycle as many as 1.2 million batteries per year and create 150 new jobs. This increased capacity was expected to be significant for the entire Central American region, which had previously been heavily reliant on secondary plants in Mexico for lead-acid battery recycling and refined lead (International Lead Association, 2009).

India.—In support of its emerging industrial economy and automotive sector, mine and refined lead production increased in 2009 compared with that in 2008 as did lead-acid battery production. Hindustan Zinc Ltd. (HZL) (Udaipar), India's leading integrated zinc and lead producer, produced 575,000 t of mined zinc and lead in concentrate at its four active mines during the 9 months that ended December 31, 2009, a 7% increase compared with production in the same period of 2008. Construction work continued on schedule at a new zinc and lead smelter in Rajpura Dariba that was expected to produce 100,000 t/yr of primary lead when completed in mid-2010. HZL was also expanding production capacities at its Kayar, Rampura Agucha, and Sindesar Khurd zinc-lead mines for progressive commissioning from mid-2010 to 2012. Upon completion of all of these projects, HZL's total zinc and lead smelting capacity would be 1,060,000 t/yr. HZL's expanded production capacity could help satisfy some of the increased demand for lead in India, which has become heavily reliant on imported lead during the past several years. ILZSG data indicated that India imported 125,000 t of lead metal in 2009, an increase of 20% compared with lead metal imports in 2008 (Hindustan Zinc Ltd., 2010, International Lead and Zinc Study Group, 2010c).

Ireland.—In the second quarter of 2009, Lundin Mining Corp. (Toronto) permanently ceased operational mining and milling at its Galmoy zinc-lead-silver mine in south-central Ireland owing to the decline in zinc prices. During the mine closure process, the company was extracting limited quantities of remnant high-grade ore for shipment to an adjacent mine for processing. These activities were expected to last until 2011 and did not affect the overall plan to permanently close the mine. Galmoy produced 6,720 t of lead in concentrates in 2009, 43% less than the 11,700 t produced in 2008 (Lundin Mining Corp., 2009; 2010, p. 19).

Italy.—Glencore International AG (Baar, Switzerland) placed the lead production line at its Porto Vesme metallurgical complex (Sardinia) on temporary care-and-maintenance status. Porto Vesme is an integrated zinc and lead smelting operation that can smelt both primary and secondary materials. Production capacity at the facility was reported to be 120,000 t/yr refined zinc and 80,000 t/yr refined lead. The zinc production line was expected to continue operating at normal production levels (O'Donovan, 2009).

Mexico.—In mid-October, Goldcorp Inc. (Vancouver, British Columbia, Canada) announced that the first lead and zinc in concentrates were produced at its Penasquito gold-silver-lead-zinc project in the northeast corner of the State of Zacatecas. The company had committed $1.6 billion to construct the mine, mills, and associated facilities since it acquired the Penasquito property in 2006. Penasquito consists of two open pit mines, Penasco and Chile Colorado, which produce oxide and sulfide ore. Development of the site proceeded on time and on budget during 2009, and the company planned to begin production in January 2010. By yearend 2009, Goldcorp estimated that Penasquito would have a mine life of 22 years and produce an estimated average of 204,000 t/yr of zinc in concentrates and 90,700 t/yr of lead in concentrates (Goldcorp Inc., 2010, p. 10–11, 58–59).

In August, JCI began construction on a new secondary lead smelter in Villa de Garcia, near Montery, in northeastern Mexico that would more than double its secondary refined lead output in Mexico. The facility was expected to initially have the capacity to produce 132,000 t/yr of refined lead and eventually could be expanded to 170,000 t/yr of refined lead. The plant would process about 13 million used lead-acid batteries per year. JCI was planning to have the smelter fully operational by the fourth quarter of 2010. Refined lead production capacity at JCI's existing secondary smelter in Cienega de Flores would be unchanged at 120,000 t/yr (CRU International Ltd., 2009b, p. 121).

Peru.—Lead mine production in 2009 was 302,000 t, a 12% decline from the 345,000 t of lead produced in 2008. Peru has been one of the leading global producers of lead concentrates for more than a decade. Several major mines scaled back lead production in 2009, and one lead-producing mine suspended operations in the spring. Volcan Compania Minera S.A.A., a leading lead producer in Peru, reportedly slowed production considerably at its open pit and underground lead mine in Cerro de Pasco in early 2009 owing to declining lead and zinc price. The company also postponed plans to expand its mining operations (CRU International Ltd., 2009b, p. 22).

In March, Glencore temporarily suspended operations at its Iscaycruz zinc-lead operations in the Central Andes owing to declining global prices for lead and zinc. Iscaycruz consisted of an open pit and underground mine that had the capacity to produce 50,000 t/yr of lead in concentrate and employed about 2,000 workers (Reuters, 2009).

In the second quarter of 2009, Doe Run Peru halted operations at its La Oroya metallurgical complex, 140 km east of Lima owing to environmental and financial problems that kept it from obtaining copper, lead, and zinc concentrates to process. La Oroya had the capacity to produce 120,000 t/yr of refined primary lead. Unsure of the company's financial stability following the late 2008 decline in commodity prices, banks froze credit lines that the smelter needed for working capital to purchase feed concentrates from suppliers. By yearend 2009, Doe Run owed its concentrate suppliers $100 million and needed an additional $150 million to complete an ongoing environmental cleanup of La Oroya in which Doe Run had already invested $307 million. Workers at La Oroya were forced to take a 90-day holiday (receiving partial pay) beginning August 1, 2009, and this holiday was later extended to January 27, 2010. It was estimated that because of these problems La Oroya produced about 25,000 t of refined lead in 2009, 78% less than the 114,000 t of refined lead produced in 2008. As of late 2009, the company was working with the Peruvian Government and its creditors to formulate a plan that would allow Doe Run to restart operations at the facility and complete its environmental obligations, but by yearend no definitive timetable had been established (CRU Lead Monitor, 2009b; Platts Metals Week, 2009a).

Romania.—In January, Mytilineos Holding S.A. (Athens, Greece) informed investors that it was temporarily suspending production at its zinc-lead metallurgical facility in Copsa Mica owing to adverse international market conditions for metals and a lack of raw materials for the production of zinc after the world's only bulk concentrate mine (McArthur River in Australia) suspended operations. The plant was operated by Sometra S.A., a subsidiary in which Mytilineos owned a 93% interest. The company drastically reduced personnel at the plant, cutting about 80% of the 1,100 employees that worked in Copsa Mica. In 2008, the last full year of operation, Copsa Mica produced about 65,000 t of refined zinc and 20,000 t of refined lead (CRU Lead Monitor, 2009a; Mytilineos Holding S.A., 2009).

Russia.—Highland Gold Mining Ltd. (HGM), (St. Helier, United Kingdom), commissioned the Novoshirokinskoye Mine in early October. Novoshirokinskoye, in Eastern Siberia, primarily produced lead and zinc concentrates with an expected capacity of about 20,000 to 28,000 t/yr of lead concentrate when operating at full production. HGM planned to test various processing technologies during the remaining portion of 2009 and ramp-up production beginning in January 2010. Novoshirokinskoye was scheduled to employ a workforce of more than 1,000 employees (Highland Gold Mining Ltd., 2009).

Zambia.—Central Recycling Ltd., a Zambian-registered company, announced that it planned to produce lead metal ingot and lead oxide from used lead-acid batteries at a new lead recycling plant that was under construction in Kabwe. The company expected that it would produce about 2,400 t/yr of lead ingot for export, and its lead oxide production capacity would depend on the availability of feedstock. Construction of the plant was expected to last until November, and production was to begin by yearend 2009 (Platts Metals Week, 2009b).

Outlook

At its spring meeting in Lisbon, Portugal, ILZSG forecast global increases in lead mine and refinery production as well as in lead consumption in 2010. Global lead mine production was expected to increase to 4.20 Mt in 2010, a 5% increase from that of 2009 owing to greater output in Australia, China, India, and Mexico. Global refined lead metal production in 2010 was expected to increase to 9.41 Mt, an 8% increase from that of 2009 owing to production increases and new plants in Brazil, China, and India. The majority of new primary and secondary refined lead capacity added in 2010 was expected to be in China.

Global consumption of refined lead in 2010 was forecast to be 9.31 Mt, a 7% increase from that of 2009, according to ILZSG. The global increase in consumption was attributed to a 9% increase in demand for refined lead in China owing to growth in the automotive, e-bike, and industrial battery sectors. Consumption in Europe, India, and the United States was expected to be slightly greater in 2010 than in 2009. In North America, the BCI forecast that total shipments of SLI lead-acid batteries would increase slightly in 2010 from those in 2009. Provided that the majority of vehicles in the current fleet continue to be operated on a regular basis, the replacement SLI battery market was expected to remain stable in the near future. Shipments of OE batteries will be heavily reliant on sales of new automobiles, which were expected to slightly increase on an annual basis during the next few years. North American sales of industrial-type lead-acid batteries were expected to increase in 2010 from sales of 2009 owing to increased demand for motive power and standby batteries from the business sector. Overall, ILZSG expected that production of refined lead would exceed consumption, and the lead market would remain in surplus of about 100,000 t by yearend 2010 (Cullen, 2010; International Lead and Zinc Study Group, 2010b).

A new research collaboration announced in mid-July had the potential to advance current lead-acid battery technology for future use in emerging technologies. Exide announced that it had entered into a cooperative research and development agreement with the U.S. Department of Energy's Savannah River National Laboratory (SRNL) and the University of Idaho to develop and commercialize improvements in lead-acid battery technology. The project was one component of a larger SRNL-sponsored research and development program supporting the Nation's energy security. SNRL expected that the collaborative efforts of the two research institutions and Exide would lead to the development of improved battery materials such as cathode plates, enhance lead-acid battery performance, and lower material costs and weight. Advancements in lead-acid battery chemistry could be used to broaden lead-acid battery opportunities in new markets for HEVs and renewable energy storage. Researchers involved with the project foresaw lead-acid batteries becoming increasingly feasible for supporting the Nation's electric grid as well as providing stand-alone backup power to alternative energy systems such as solar and wind. Potential growth existed in the use of lead in batteries for microhybrid electric vehicles that have automatic stop-start functionality to cut engine power and operate on battery power when idling, in lead-cooled nuclear powerplants, and as a material component in thermoelectric energy conversion (Exide Technologies, 2009a).

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TABLE 1

SALIENT LEAD STATISTICS[1]

		2005	2006	2007	2008	2009
United States:						
Production:						
Mine, recoverable lead content:[2]						
Quantity	metric tons	426,000	419,000	434,000	399,000	395,000
Value	thousands	$574,000	$715,000	$1,180,000	$1,060,000	$757,000
Primary lead, refined content, domestic ores and base bullion	metric tons	143,000	153,000	123,000	135,000	103,000
Secondary lead, lead content	do.	1,150,000	1,160,000	1,180,000	1,140,000 [r]	1,110,000
Exports, lead content:						
Lead ore and concentrates	do.	390,000	298,000	300,000	277,000	287,000
Lead materials, excluding scrap	do.	64,600	68,500	56,500	74,800 [r]	82,000
Imports for consumption, lead content:						
Lead in base bullion	do.	29	539	1,990	2,740	844
Lead in pigs and bars	do.	298,000	331,000	263,000	309,000	251,000
Stocks, December 31, lead content:						
Primary lead	do.	W	W	W	W	W
At consumers and secondary smelters	do.	46,800	54,800	39,000	72,500 [r]	63,500
Consumption of metal, primary and secondary, lead content	do.	1,490,000	1,490,000	1,570,000	1,440,000 [r]	1,290,000
Price:						
North American Producer average, delivered[3]	cents per pound	61.03	77.40	123.84	120.33	86.87
London Metal Exchange, pure lead, cash average[3]	do.	44.23	58.00	117.00	94.79	77.95
World:						
Production, gross weight:						
Mine	metric tons	3,470,000 [r]	3,590,000 [r]	3,690,000 [r]	3,860,000 [r]	3,860,000
Primary refinery	do.	3,500,000 [r]	3,720,000 [r]	3,790,000 [r]	4,080,000 [r]	3,960,000 [e]
Secondary refinery	do.	3,950,000 [r]	4,050,000 [r]	4,230,000 [r]	4,430,000 [r]	4,680,000 [e]

[e] Estimated. [r] Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Lead recoverable after smelting and refining. Data in table 13 represent lead in concentrate.

[3] Platts Metals Week.

TABLE 2
MINE PRODUCTION OF RECOVERABLE LEAD IN THE UNITED STATES, BY STATE[1]

(Metric tons, lead content)

State	2008	2009
Alaska and Missouri	360,000	370,000
Idaho, Montana, Washington	38,600	24,900
Total	399,000	395,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 3
LEADING LEAD-PRODUCING MINES IN THE UNITED STATES IN 2009, IN ORDER OF OUTPUT[1]

Rank	Mine	County and State	Operator	Source of lead
1	Red Dog	Northwest Arctic, AK	Teck Alaska Inc.	Zinc-lead ore.
2	Brushy Creek	Reynolds, MO	Doe Run Resources Corp.	Lead ore.
3	Fletcher	do.	do.	Do.
4	Buick	Iron, MO	do.	Do.
5	Viburnum (#29 and #35)	Washington and Iron, MO	do.	Do.
6	Greens Creek	Juneau, AK	Hecla Mining Co.	Zinc-silver ore.
7	Lucky Friday	Shoshone, ID	do.	Silver ore.
8	Sweetwater	Reynolds, MO	Doe Run Resources Corp.	Lead ore.
9	Galena	Shoshone, ID	U.S. Silver Corp.	Silver ore.
10	Montana Tunnels	Jefferson, MT	Apollo Gold Corp.	Gold ore.
11	Pend Oreille	Pend Oreille, WA	Teck Washington Inc.	Zinc-lead ore.

Do., do. Ditto.

[1] The mines on this list accounted for 100% of the U.S. mine production in 2009.

TABLE 4
LEAD RECOVERED FROM SCRAP PROCESSED IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY[1]

(Metric tons, lead content, unless otherwise specified)

		2008	2009
Kind of scrap:			
New scrap:			
Lead-base		18,600	20,100
Copper-base		NA	NA
Tin-base		1,530 r	1,530
Total		20,100	21,600
Old scrap:			
Battery-lead		1,070,000 r	1,040,000
All other lead-base		52,500	47,400
Copper-base		NA	NA
Total		1,120,000 r	1,090,000
Grand total		1,140,000 r	1,110,000
Form of recovery:			
As soft lead		1,000,000	960,000
In antimonial lead		140,000	151,000
In other lead alloys		2,410	(3)
In copper-base alloys		NA	NA
Total:			
Quantity		1,140,000 r	1,110,000
Value[2]	thousands	$3,040,000 r	$2,130,000

rRevised. NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Value based on average quoted price of common lead.

[3] Included with "As soft lead."

TABLE 5
U.S. CONSUMPTION OF LEAD, BY PRODUCT[1]

(Metric tons, lead content)

SIC[2] code	Product	2008	2009
	Metal products:		
3482	Ammunition, shot and bullets	67,400 r	67,900
	Bearing metals:		
35	Machinery except electrical	W	W
371	Motor vehicles and equipment	W	W
37	Other transportation equipment	W	W
	Total	1,250	1,100
3351	Brass and bronze, billets and ingots	2,460	1,370
36	Cable covering, power and communication	(3)	(3)
15	Calking lead, building construction	(3)	(3)
	Casting metals:		
36	Electrical machinery and equipment	W	W
371	Motor vehicles and equipment	W	W
37	Other transportation equipment	W	W
3443	Nuclear radiation shielding	W	W
	Total	20,100	15,900
	Pipes, traps, other extruded products:		
15	Building construction	1,190 r	1,130
3443	Storage tanks, process vessels, etc.	(4)	(4)
	Total	1,190 r	1,130
	Sheet lead:		
15	Building construction	16,500	16,300
3443	Storage tanks, process vessels, etc.	W	W
3693	Medical radiation shielding	W	W
	Total	26,400 r	25,400
	Solder:		
15	Building construction	W	W
341	Metal cans and shipping containers	W	W
367	Electronic components, accessories, and other electrical equipment	6,290 r	6,160
371	Motor vehicles and equipment	W	W
	Total	6,610 r	6,450
	Storage batteries:		
3691	Storage battery grids, post, etc.	575,000 r	389,000
3691	Storage battery oxides	715,000 r	750,000
	Total storage batteries	1,290,000	1,140,000
27	Type metal, printing and allied industries	(3)	(3)
34	Other metal products[5]	7,670 r	5,790
	Grand total	1,420,000 r	1,260,000
	Other oxides:		
285	Paint	W	W
32	Glass and ceramics products	W	W
28	Other pigments and chemicals	W	W
	Total	10,700	10,100
	Miscellaneous uses	10,800	12,200
	Grand total	1,440,000 r	1,290,000

[r] Revised. W Withheld to avoid disclosing company proprietary data; included in appropriate totals.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] SIC Standard Industrial Classification.

[3] Included with "Metal products: Other Metal products."

[4] Included with "Metal products: Sheet lead: Building construction" to avoid disclosing company proprietary data.

[5] Includes lead consumed in foil, collapsible tubes, annealing, galvanizing, plating, electrowinning, and fishing weights.

TABLE 6
U.S. CONSUMPTION OF LEAD IN 2009, BY STATE[1, 2]

(Metric tons, lead content)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California and Washington	25,800	1,250	2,380	--	29,400
Illinois	8,150	17,400	--	--	25,600
Iowa, Michigan, Missouri	4,760	--	W	--	4,760
Ohio and Pennsylvania	114,000	70,700	41,500	W	227,000
Arkansas and Texas	71,200	24,200	W	--	95,400
Alabama, Georgia, Oklahoma	31,600	8,310	W	--	39,900
Indiana, Kansas, Kentucky, Minnesota, Nebraska, Tennessee, Wisconsin	158,000	53,200	32,600	W	244,000
Connecticut, Maryland, New Jersey, New York, North Carolina, South Carolina	4,750	2,320	813	--	7,880
Various States	450,000	68,200	94,600	538	613,000
Total	869,000	246,000	172,000	538	1,290,000

W Withheld to avoid disclosing company proprietary data; included in "Various States." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes lead that went directly from scrap to fabricated products.

TABLE 7
U.S. CONSUMPTION OF LEAD IN 2009, BY CLASS OF PRODUCT[1, 2]

(Metric tons, lead content)

Product	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	52,200	66,700	W	W	125,000
Storage batteries	794,000	179,000	166,000	--	1,140,000
Miscellaneous[3]	22,300	W	W	W	22,300
Total	869,000	246,000	172,000	538	1,290,000

W Withheld to avoid disclosing company proprietary data; included in "Total." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes lead that went directly from scrap to fabricated products.

[3] Included in "Miscellaneous" are other oxides and gasoline additives.

TABLE 8
STOCKS OF LEAD AT CONSUMERS AND SECONDARY SMELTERS IN THE UNITED STATES, DECEMBER 31[1, 2]

(Metric tons, lead content)

Year	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
2008	36,000 r	20,100 r	W	W	72,500 r
2009	33,200	20,000	W	W	63,500

r Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes stocks at primary refineries.

TABLE 9
PRODUCTION AND SHIPMENTS OF LEAD PIGMENTS AND OXIDES IN THE UNITED STATES[1, 2]

(Metric tons and dollars)

	2008				2009			
	Production		Shipments[e]		Production		Shipments[e]	
Product	Gross weight	Lead content	Quantity (lead content)	Value[3]	Gross weight	Lead content	Quantity (lead content)	Value[3]
Litharge, red lead and white lead, dry	--	--	2,700	$6,330,000	--	--	2,520	$3,400,000
Leady oxide	740,000	703,000	NA	NA	757,000	719,000	NA	NA
Total	740,000	703,000	NA	NA	757,000	719,000	NA	NA

[e] Estimated. NA Not available. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes basic lead sulfate to avoid disclosing company proprietary data.

[3] At plant, exclusive of container.

TABLE 10
U.S. IMPORTS FOR CONSUMPTION OF LEAD PIGMENTS AND COMPOUNDS, BY KIND[1]

Kind	Quantity (metric tons, lead content)	Value (thousands)
2008:		
Chrome yellow, molybdenum orange pigments, lead-zinc chromates	1,500	$8,700
Litharge	1,900	6,410
Glass frits (undifferentiated)	22,800	47,300
Total	26,200	62,400
2009:		
Chrome yellow, molybdenum orange pigments, lead-zinc chromates	1,270	6,840
Litharge	971	2,570
Glass frits (undifferentiated)	25,800	37,400
Total	28,100	46,800

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 11
U.S. EXPORTS OF LEAD, BY COUNTRY[1]

Country	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)
Ore and concentrates, lead content:				
Belgium	117	$150	646	$268
Canada	48,500	78,800	44,700	60,700
China	132,000	84,800	159,000	151,000
Hong Kong	--	--	118	28
India	--	--	115	53
Japan	24,700	12,700	20,500	16,200
Korea, Republic of	54,300	35,400	61,100	45,400
Mexico	16,700	30,500	545	885
Saudi Arabia	--	--	148	46
United Arab Emirates	109	34	--	--
Vietnam	651	203	--	--
Other	7 [r]	7 [r]	38	30
Total	277,000	243,000	287,000	275,000
Base bullion, lead content:				
Japan	82	1,070	--	--
Mexico	519	945	25	99
Other	13 [r]	25	9	14
Total	614	2,040	34	113
Unwrought lead and lead alloys, lead content:				
Belgium	4,250	3,710	9,550	8,500
Brazil	475	408	2,200	2,440
Canada	7,650	11,500	5,390	8,780
Chile	343	367	955	1,240
China	498	411	252	232
El Salvador	110	166	62	72
Germany	1,490	1,210	82	55
Indonesia	194	180	--	--
Ireland	46	28	16	10
Israel	1,150	1,220	64	42
Japan	75	600	87	1,130
Korea, Republic of	1,210	2,260	48	27
Malaysia	72	111	--	--
Mexico	45,900	92,600	58,400	56,900
Panama	--	--	41	62
Philippines	2,340	1,710	46	64
Spain	1,290	1,120	198	225
Taiwan	123	76	4	4
Thailand	230	198	--	--
Turkey	(2)	10	28	17
United Kingdom	204	914	29	37
Venezuela	83	72	--	--
Other	285 [r]	328 [r]	146	207
Total	68,100	119,000	77,600	80,100

See footnotes at end of table.

TABLE 11—Continued

U.S. EXPORTS OF LEAD, BY COUNTRY[1]

Country	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)
Wrought lead and lead alloys, lead content:				
Canada	1,760	$3,030	1,370	$3,090
Chile	25	48	244	942
China	197	260	165	231
France	98	313	(2)	13
Germany	120	177	24	46
Haiti	134	123	162	160
India	435	560	669	731
Japan	12	25	65	288
Korea, Republic of	127	209	108	449
Malaysia	37	29	9	10
Mexico	1,770	3,110	705	1,170
Singapore	81	124	23	27
Spain	39	79	12	12
United Kingdom	873	1,040	599	786
Other	445 r	745 r	156	337
Total	6,150	9,880	4,310	8,280
Scrap, gross weight:				
Albania	246	70	169	58
Bangladesh	1,190	441	136	30
Belgium	260	2,000	--	--
Brazil	73	23	20	7
Canada	115,000	60,500	79,000	37,700
China	8,730	4,520	5,150	3,660
Colombia	1,520	368	142	43
Ecuador	232	56	103	23
France	194	45	7	11
Germany	53	45	881	911
Guatemala	--	--	84	28
Honduras	992	219	249	69
Hong Kong	38	29	464	180
India	20,600	6,810	11,000	2,900
Korea, Republic of	20,800	15,900	31,800	21,500
Mexico	466	116	366	556
Nicaragua	143	32	173	94
Pakistan	574	191	971	184
Panama	59	50	225	52
Paraguay	167	120	70	21
Saudi Arabia	90	76	121	123
Spain	36	19	700	379
Taiwan	--	--	4,320	1,470
United Kingdom	1,490	498	477	105
Venezuela	188	65	493	201
Vietnam	--	--	1,530	488
Other	2,100 r	597 r	1,630	1,700
Total	175,000	92,800	140,000	72,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 12
U.S. IMPORTS FOR CONSUMPTION OF LEAD, BY COUNTRY[1]

Country	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)
Base bullion:				
Colombia	543	$1,180	--	--
Mexico	2,040	4,090	810	$2,200
Venezuela	20	46	--	--
Other	132 r	281 r	34	52
Total	2,740	5,590	844	2,250
Pigs and bars, lead content:				
Canada	219,000	492,000	205,000	354,000
China	200	372	--	--
France	7,050	14,600	267	1,080
Germany	1,810	3,300	11	32
Italy	194	554	--	--
Kazakhstan	2,990	5,900	3,500	4,460
Mexico	58,100	97,400	41,100	47,200
Peru	10,600	24,600	991	1,210
Russia	647	2,010	131	240
United Kingdom	8,030	15,700	--	--
Venezuela	1,260	3,370	--	--
Other	85 r	186 r	112	154
Total	309,000	660,000	251,000	408,000
Reclaimed scrap, including ash and residues, lead content:				
Canada	739	1,420	785	1,900
China	--	--	32	26
Colombia	--	--	105	212
Mexico	438	378	348	357
Russia	37	89	18	28
United Kingdom	1	8	--	--
Other	77	148	46	99
Total	1,290	2,040	1,330	2,620
Wrought lead, all forms, including wire and powders, gross weight:				
Argentina	362	1,060	269	502
Canada	291	1,060	164	501
France	1,010	2,560	--	--
Germany	778	5,220	709	3,740
Mexico	75	169	--	--
New Zealand	177	1,380	15	229
Russia	29	28	--	--
United Kingdom	442	2,100	123	716
Other	86 r	390 r	63	260
Total	3,250	14,000	1,340	5,950

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 13
LEAD: WORLD MINE PRODUCTION OF LEAD IN CONCENTRATE, BY COUNTRY[1, 2]

(Metric tons, lead content)

Country[3]	2005	2006	2007	2008	2009
Argentina	10,683	12,064	17,045	20,788 [r]	20,000
Australia	767,000	686,000	641,000	645,000	566,000
Bolivia	11,231	11,955	22,798	81,602	86,394
Bosnia and Herzegovina[e]	1,000 [r]	1,000 [r]	4,000 [r]	3,000 [r]	3,000 [e]
Brazil	23,616	15,764	24,574	24,600	24,800
Bulgaria[e]	13,000 [r]	10,000 [r]	15,000 [r]	15,000 [r]	18,000
Burma[e]	2,000	2,000	2,000	3,600 [r]	3,500
Canada	79,254	83,096	75,135	98,974	68,761
Chile	878	672	1,305	3,985	1,511
China[e]	1,140,000	1,330,000	1,410,000	1,500,000	1,600,000
Georgia[e]	400	400	400	400	400
Greece[e]	1,500	10,500	15,000	16,000	16,000
Guatemala	23	28	363	500 [r, e]	--
Honduras	10,488	11,775	10,215	10,000 [e]	10,000 [e]
India	60,400	69,200	77,500	87,300	92,000
Iran[e, 4]	23,000	24,000 [5]	25,000	20,000	20,000
Ireland[e]	63,800	62,000	54,100	50,200 [r]	50,000
Italy[e]	800	800	800	800	800
Japan	3,437	777	--	--	--
Kazakhstan	31,000	48,100	40,200	39,000	39,400
Korea, North[e]	13,000 [r]	13,000 [r]	13,000 [r]	13,000 [r]	13,000
Korea, Republic of	50	17	12	449 [r]	50 [e]
Macedonia	-- [e]	15,600	32,000	34,000 [r, e]	52,000
Mexico	134,388	120,450	120,000	100,725	143,838
Morocco	45,800	53,000	44,800	40,000	40,000 [e]
Namibia	14,320	11,830	10,543 [r]	14,062 [r]	14,100 [e]
Peru	319,345	313,325	329,154	345,109	302,412
Poland	75,100	58,500	59,900	62,200	60,000 [e]
Romania	11,610	6,269	1,000 [r]	-- [r, e]	-- [e]
Russia[e]	36,000	36,000	50,000	60,000	70,000
Serbia[e]	1,000 [6]	1,000	1,000	1,000	1,000
South Africa	42,159	48,273	41,857	46,440	49,149
Sweden	61,000	76,800	62,100	60,000	60,000 [e]
Tajikistan[e]	800	800	800	800	800
Tunisia[e]	8,708 [5]	--	--	--	--
Turkey[e]	19,000	15,000	20,000	30,000	11,000
United Kingdom[e]	500	500	500	500	500
United States	437,000	429,000	444,000	410,000	406,000
Vietnam	7,700 [r]	14,900 [r]	19,200 [r]	19,100 [r]	19,000 [e]
Total	3,470,000 [r]	3,590,000 [r]	3,690,000 [r]	3,860,000 [r]	3,860,000

[e] Estimated. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 7, 2010.

[3] In addition to the countries listed, lead is also produced in Nigeria, but information is inadequate to formulate reliable estimates of output levels.

[4] Year beginning March 21 of that stated.

TABLE 13—Continued
LEAD: WORLD MINE PRODUCTION OF LEAD IN CONCENTRATE, BY COUNTRY[1, 2]

[5] Reported figure.

[6] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

TABLE 14
LEAD: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009
Algeria, secondary[e]	5,000	5,000	5,000	5,000	5,000
Argentina:					
Primary	10,607	12,064	11,588 [r]	13,482 [r]	13,000 [e]
Secondary	35,000	37,000	49,000 [r]	59,000 [r]	55,000 [e]
Total	45,607	49,064	60,588 [r]	72,482 [r]	68,000 [e]
Australia:					
Primary	230,000	206,000	202,000	221,000	204,000
Secondary[e]	33,000 [5]	27,000	27,000	27,000	25,000
Total	263,000	233,000	229,000	248,000	229,000
Austria, secondary	24,357 [r]	28,120 [r]	28,564 [r]	26,902 [r]	20,000 [e]
Belgium:[e]					
Primary[4]	63,400	34,000	97,200	80,966 [r, 5]	80,000
Secondary	20,000	20,000	20,000	20,000	20,000
Total	83,400	54,000	117,000 [r]	101,000 [r]	100,000
Bolivia	33	318 [r]	301	473 [r]	269 [e]
Brazil, secondary	104,904	142,653	142,450	143,000	143,500
Bulgaria:[e]					
Primary	68,000	64,000	73,000 [5]	73,000	70,000
Secondary	13,000	12,000	14,000 [5]	14,000	13,000
Total	81,000	76,000	87,000 [5]	87,000	83,000
Burma, primary	907	537	165	202	200 [e]
Canada:					
Primary	109,996	115,989	95,577	105,526	101,484
Secondary	120,241	134,475	141,111	153,549	157,370
Total	230,237	250,464	236,688	259,075	258,854
China:[e]					
Primary	1,850,000	2,130,000	2,140,000	2,350,000	2,480,000
Secondary	537,000	590,000	650,000	850,000	1,230,000
Total	2,390,000	2,720,000	2,790,000	3,200,000	3,710,000
Colombia, secondary[e]	12,000	10,000	10,000	10,000	10,000
Czech Republic, secondary[e]	26,000	29,000 [r]	34,000 [r]	36,000 [r]	36,000
El Salvador, secondary[e]	10,000	10,000	10,000	10,000	10,000
Estonia, secondary	7,000 [e]	9,000	10,000	10,000 [e]	10,000 [e]
France:					
Primary	--	4,000	4,000 [e]	4,000 [e]	4,000 [e]
Secondary	104,979	100,195	100,200	88,000	88,000 [e]
Total	104,979	104,195	104,200	92,000	92,000 [e]
Germany:					
Primary	118,778	113,760 [r]	110,934	113,200 [r]	105,000 [e]
Secondary	298,915 [r]	265,190 [r]	294,147	301,900 [r]	286,000 [e]
Total	417,693 [r]	378,950 [r]	405,081	415,100 [r]	391,000 [e]
Greece, secondary[e]	4,000	5,000	5,000	5,000	4,000
India:					
Primary	24,000	49,000	54,000	62,000	65,000
Secondary	35,000	56,000	70,000	76,000	78,000
Total	59,000	105,000	124,000	138,000	143,000
Indonesia, secondary	18,000	19,000	18,500	18,500	18,000

See footnotes at end of table.

TABLE 14—Continued
LEAD: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009
Iran:[e]					
Primary	21,000	25,000	25,000	20,000 [r]	20,000
Secondary	50,000	50,000	50,000	55,000 [r]	55,000
Total	71,000	75,000	75,000	75,000 [r]	75,000
Ireland, secondary[e]	20,000	22,000	22,500	22,500	22,500
Israel, secondary	28,000	25,000	25,000	27,000 [r]	27,000 [e]
Italy:					
Primary	49,500	34,600	45,000	47,800	15,000 [e]
Secondary	162,000	155,900	165,000	164,000	134,000 [e]
Total	211,500	190,500	210,000	211,800	149,000 [e]
Japan:					
Primary	106,638	108,271	104,527	107,005 [r]	105,000
Secondary	167,980	171,143	171,795	172,454 [r]	170,000
Total	274,618	279,414	276,322	279,459 [r]	275,000
Kazakhstan, primary and secondary	135,446	115,974	117,641	105,853	90,000 [e]
Kenya, secondary[e]	1,000	1,000	1,000	1,000	1,000
Korea, North, primary and secondary[e]	9,000	9,000	9,000	9,000	9,000
Korea, Republic of:					
Primary	180,784	163,379	195,022	244,137 [r]	200,000 [e]
Secondary[e]	55,800	56,000	60,000	60,000	60,000
Total	236,584	219,379	255,022	304,137 [r]	260,000 [e]
Malaysia, secondary[e, 6]	71,000	73,000	73,000	73,000	70,000
Mexico:					
Primary[7]	116,539	102,498	102,000 [e]	89,838	100,361
Secondary[e]	110,000	110,000	110,000	110,000	110,000
Total	226,539	212,498	212,000 [e]	199,838	210,361
Morocco:[e]					
Primary	35,000	38,000	45,000	45,000	45,000
Secondary	4,000	3,000	3,000	3,000	3,000
Total	39,000	41,000	48,000	48,000	48,000
Netherlands, secondary[e]	20,000	18,000	17,000	17,000	17,000
New Zealand, secondary[e]	7,000	7,000	7,000	9,000 [r]	13,000
Nigeria, secondary[e]	5,000	5,000	5,000	5,000	5,000
Pakistan, secondary[e]	3,200	3,100	3,000	3,000	3,000
Peru, primary	122,079	120,311	116,774	114,259	26,000 [e]
Philippines, secondary[e]	30,000	30,000	30,000	30,000	30,000
Poland:[e]					
Primary	29,500 [r]	26,200 [r]	37,200 [r]	40,000 [r]	35,000
Secondary	51,500	56,600 [r]	67,000 [r]	68,000 [r]	60,000
Total	81,000 [r]	82,800 [r]	104,000 [r]	108,000 [r]	95,000
Portugal, secondary[e]	4,000	3,000	3,000	3,000	3,000
Romania:[e]					
Primary	32,900	29,100	34,000	34,000	12,000
Secondary	5,000	5,000	5,000	5,000	5,000
Total	37,900	34,100	39,000	39,000	17,000
Russia, primary and secondary[e]	66,000	78,000	94,000	80,000	73,000
Saudi Arabia, secondary[e]	36,000 [5]	38,000	38,000	38,000	38,000
Serbia, primary and secondary[e]	2,400 [r, 8]	2,600 [r]	1,200 [r]	1,000 [r]	1,000

See footnotes at end of table.

TABLE 14—Continued

LEAD: WORLD REFINERY PRODUCTION, BY COUNTRY[1,2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009
Slovenia, secondary^{e}	15,000	15,000	15,000	15,000	14,000
South Africa, secondary	65,300 ^{r}	67,000	59,000 ^{r}	62,000 ^{r}	55,000 ^{e}
Spain, secondary^{e}	110,000	110,000	110,000	110,000	110,000
Sweden:^{e}					
Primary	27,400	26,000	26,000	26,000	26,000
Secondary	45,600	40,000	40,000	40,000	40,000
Total	73,000	66,000	66,000	66,000	66,000
Switzerland, secondary^{e}	9,000	9,600 [5]	9,000	8,000	8,000
Taiwan, secondary	55,000	55,000	55,000	55,000	40,000
Thailand, secondary	61,100	61,160	73,159	73,303 ^{r}	73,000 ^{e}
Trinidad and Tobago, secondary^{e}	1,000	1,000	1,000	1,000	1,000
Tunisia, secondary^{e}	7,000	8,000	9,000	9,000	7,000
Turkey, secondary^{e}	6,000	6,000	6,000	6,000	6,000
Ukraine, secondary^{e}	6,000	6,000	6,000	6,000	6,000
United Arab Emirates, secondary^{e}	2,000	2,000	2,000	2,000	2,000
United Kingdom:					
Primary	161,350	163,700	150,000	150,000	150,000
Secondary	143,000	144,000	150,000	144,000	144,000
Total	304,350	307,700	300,000	294,000	294,000
United States:					
Primary	143,000	153,000	123,000	135,000	103,000
Secondary	1,150,000	1,160,000	1,180,000	1,140,000 ^{r}	1,110,000
Total	1,300,000	1,310,000	1,300,000	1,280,000	1,210,000
Venezuela, secondary^{e}	30,000	30,000	30,000	30,000	30,000
Zambia, secondary^{e}	1,000	1,000	1,000	1,000	1,000
Grand total	7,660,000 ^{r}	7,970,000 ^{r}	8,250,000 ^{r}	8,700,000 ^{r}	8,820,000
Of which:					
Primary	3,500,000	3,720,000 ^{r}	3,790,000 ^{r}	4,080,000 ^{r}	3,960,000
Secondary	3,950,000 ^{r}	4,050,000 ^{r}	4,230,000	4,430,000 ^{r}	4,680,000
Undifferentiated	213,000 ^{r}	206,000 ^{r}	222,000	196,000	173,000

^{e}Estimated. ^{r}Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 7, 2010. Data included represent the total output of refined lead by each country, whether derived from ores and concentrates (primary) or scrap (secondary), and include the lead content of antimonial lead but exclude, to the extent possible, simple remelting of scrap.

[3] In addition to the countries listed, Egypt and Iraq produced secondary lead, but output is not officially reported; available general information is inadequate for the formulation of reliable estimates of output levels.

[4] Derived by calculating reported total lead output plus exports of lead bullion minus imports of lead bullion.

[5] Reported figure.

[6] Metal Reclamation Industries' secondary lead smelter is receiving some primary mine concentrates from the Magellan Mine (Australia). The ore minerals are lead oxides and can be smelted at a secondary smelter.

[7] Includes lead content in antimonial lead.

[8] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

LIME

By M. Michael Miller

Domestic survey data and tables were prepared by Shonta E. Osborne, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2009, the U.S. economy suffered the effects of the longest recession since the 1930s, which began in December 2007 and ended by the summer of 2009 (National Bureau of Economic Research, 2008). Initially, the recovery was slow, as the economy grew at an annual rate of only 2.2% in the third quarter, but the growth rate picked up noticeably in the fourth quarter, expanding at a 5.7% rate (Rampell, 2010).

As a result of the severe economic downturn, compared with that of the previous year, lime sold and used in the United States decreased by 21% to a total of 15.8 million metric tons (Mt) (17.4 million short tons). The value of U.S. lime production, however, decreased by only 9.8% or $180 million to $1.66 billion (table 1). The disproportionate decrease in production compared with the decrease in value was the result of average price increases of nearly 14% compared with those of 2008. With a few exceptions, consumption of lime in most markets recorded large decreases compared with that of 2008.

The term lime as used throughout this chapter refers primarily to six chemicals produced by the calcination of high-purity calcitic or dolomitic limestone followed by hydration where necessary. There are two high-calcium forms—high-calcium quicklime (calcium oxide, CaO) and high-calcium hydrated lime [calcium hydroxide, $Ca(OH)_2$]. There are four dolomitic forms—dolomitic quicklime (CaO•MgO), dolomitic hydrate type N [$Ca(OH)_2$•MgO], dolomitic hydrate type S [$Ca(OH)_2$•$Mg(OH)_2$], and refractory dead-burned dolomite (CaO•MgO). Lime also can be produced from a variety of calcareous materials, such as aragonite, chalk, coral, marble, and shell. It also is regenerated (produced as a byproduct) by paper mills, carbide plants, and water-treatment plants. Regenerated lime, however, is beyond the scope of this report.

Legislation and Government Programs

The U.S. Environmental Protection Agency (EPA) published regulations to require reporting of greenhouse gas emissions from all sectors of the economy effective December 29, 2009 (U.S. Environmental Protection Agency, 2009a). The final rule applied to fossil fuel suppliers and industrial gas suppliers, direct greenhouse gas emitters, and manufacturers of heavy-duty and off-road vehicles and engines. As a direct greenhouse gas emitter, this rule would apply to the lime industry. The rule did not require control of greenhouse gases; it required only that sources above certain threshold levels monitor and report emissions. The rule covered carbon dioxide emissions (CO_2) from the calcination of limestone from all kilns combined, which was a significant change from the proposed rule published October 27, 2009 (Environmental Protection Agency, 2009b), which would have required lime producers to calculate CO_2 emissions from each kiln (a much more difficult and expensive process). The final rule also covered emissions of CO_2, methane, and nitrous oxides from the combustion of fuels from each lime kiln and each stationary combustion unit (National Lime Association, 2009).

Production

Domestic production data for lime were derived by the U.S. Geological Survey (USGS) from a voluntary survey of U.S. operations. The survey was sent to primary producers of quicklime and hydrate, but in order to avoid double counting, it was not sent to independent hydrators that purchase quicklime for hydration. Quantity data were collected for 28 specific and general end uses, and value data were collected by type of lime, such as high-calcium or dolomitic. Because value data were not collected by end use, value data listed in table 3 were determined by calculating the average value per metric ton of lime sold or used for each respondent and then multiplying that figure by the quantity of lime that the respondent reported sold or used for each end use. Table 3 lists the total quantity sold or used for an end use and the total value of the quicklime and hydrate sold or used for that end use calculated as described above. A similar methodology using average hydrate values was used to calculate the value of hydrate sold and used listed in table 4.

In 2009, of the more than 90 operations that were canvassed, responses were received for 78 plants, representing 96% of the total sold or used by producers. Production data for the nonrespondents were estimated based on prior-year production figures and other information or were included with data reported for other operations.

Lime is a basic chemical that was produced as quicklime in 29 States and Puerto Rico. During 2009, quicklime was produced at 73 lime plants that operated all or part of the year, and included 31 plants with collocated hydrating plants. Hydrated lime also was produced at 14 standalone hydrating facilities, including 3 plants where the kilns had been shut down and hydrate was manufactured from quicklime produced offsite. These numbers do not necessarily agree with the number of plants reported in tables 1 and 2 because for data collection purposes some company operations have been combined at the respondent's request. In a few States with no quicklime production, hydrating plants used quicklime shipped from other States. There was also a small number of slurry plants where lime was converted to liquid form by the addition of water prior to sale; this is sometimes called milk-of-lime. In addition to stationary slurry plants, there were mobile hot lime slurry production systems designed to slake quicklime or slurry hydrated lime to the percent solids required for each job. Missouri was the only State with production that exceeded 2 Mt; States with production between 1 and 2 Mt were, in descending order, Alabama, Kentucky, Ohio, Nevada, and Texas.

Total lime sold or used by domestic producers in 2009 was 15.8 Mt, a decrease of 4.1 Mt or 21% compared with that of 2008. Production included the commercial sale or captive consumption of quicklime, hydrated lime, and dead-burned refractory dolomite. Data were incomplete on production of hydrated lime because some producers do not report data on downstream hydrating plants. Traditionally, the majority of U.S. lime production sold and used is in the form of high-calcium quicklime. In 2009, the production of high-calcium quicklime decreased by 21% to 11.8 Mt (13.0 million short tons), and accounted for 75% of total production. The production of high-calcium hydrate decreased by 18%. Production of dolomitic quicklime decreased by 21%, while production of dolomitic hydrate decreased by 27%. Commercial sales decreased to 14.5 Mt (16.0 million short tons), and captive consumption decreased to 1.26 Mt (1.39 million short tons).

As a result of the recession and severe economic downturn, a significant number of lime plants were idle part or all of 2009. Plants idle all year included Carmeuse Lime & Stone's Grand River, OH, South Chicago, IL, and Winchester, VA, plants; Chemical Lime Co.'s Douglas, AZ, Grantsville, UT, and Tenmile, ID, plants; and Jomico LLC's Bonne Terre, MO, plant. Plants that operated intermittently or were shut down early in the year included Carmeuse's Manitowoc, WI, and River Rouge, MI, plants, and Chemical Lime's Alabaster, AL, plant and Belen, NM, hydrator. In addition, individual kilns were idled at some large multikiln plants to reduce unneeded capacity.

At yearend, the top 10 companies were, in descending order of U.S. lime production, Carmeuse, Chemical Lime, Graymont Ltd., Mississippi Lime Co., United States Lime & Minerals, Inc., Martin Marietta Magnesia Specialties LLC, Western Lime Corp., Southern Lime Co., American Crystal Sugar Co., and ArcelorMittal USA Inc. These companies reported production from 45 lime plants and 12 separate hydrating plants and accounted for 90% of the combined commercial lime sales and 86% of total lime production.

Consumption

In early 2009, the U.S. economy was mired in the longest recession since the Great Depression of the 1930s, and lime sales reflected the Nation's economic conditions by recording large decreases in most markets. Signs of a recovery were finally felt in the fourth quarter of 2009 when the steel market began to recover. The boost lime sales received in the fourth quarter resulted in apparent consumption of 16.1 Mt. The approximate breakdown of consumption by general end-use sectors was as follows: 34% for environmental uses, 31% for metallurgical uses, 25% for chemical and industrial uses, 9% for construction uses, and 1% for refractory dolomite (table 3). These end-use data were based on lime sold and used by domestic producers and do not include lime imports. Consumption for metallurgical uses decreased by 2.34 Mt and accounted for 57% of the overall decrease in lime consumption. Other market sectors recorded significant but much smaller decreases—construction [649,000 metric tons (t)], environmental (560,000 t), and chemical and industrial (505,000 t).

Commercial sales accounted for 90% of total lime consumption and 92% of domestic production. Captive lime accounted for the remainder of consumption and was used mainly in the production of steel in basic oxygen furnaces (BOF), sugar refining, magnesia production, and refractories. Almost all data on captive lime consumption are withheld to avoid disclosing company proprietary information. As a result, table 3 lists the total quantity and value of lime by end use. End uses with captive consumption are listed in footnote 4 of the table.

In steel refining, quicklime is used as a flux to remove impurities, such as phosphorus, silica, and sulfur. The steel industry accounted for 24% of lime sold by domestic lime companies and the lime produced and used by ArcelorMittal USA from its captive lime plant. As a result of the recession, operating rates of U.S. steel mills decreased dramatically beginning in late 2008. In December 2008, raw steel capacity utilization had dropped to its lowest point at only 41%. It averaged less than 44% through the first 6 months of 2009, and it slowly increased during the second half of the year but still only averaged 62% in the fourth quarter (Fenton, 2009, 2010). In 2009, lime consumption from domestic sources for steelmaking and related uses was 3.8 Mt, a decrease of 35% compared with that of 2008. This large decrease parallels the decrease in U.S. raw steel production of 37% to 58.2 Mt in 2009 from 91.9 Mt in 2008 (M.D. Fenton, U.S. Geological Survey, written commun., April 16, 2010).

In nonferrous metallurgy, lime is used in the beneficiation of copper ores to neutralize the acidic effects of pyrite and other iron sulfides and to maintain the proper pH in the flotation process. Lime is used to process alumina and magnesia, to extract uranium from gold slimes, to recover nickel by precipitation, and to control the pH of the sodium cyanide solution used to leach gold and silver from the ore. Gold and silver are recovered using heap leaching and by conventional milling and subsequent leaching of the slurry. The sodium cyanide solution dissolves gold from the ore and forms a stable gold-cyanide complex, and the gold can then be separated through the use of highly activated carbon. Heap leaching involves crushing the ore, mixing it with lime for pH control and agglomeration, and stacking the ore in heaps on specially prepared pads for treatment with cyanide solution. Lime is used to maintain the pH of the cyanide solution at a level between 10 and 11 to maximize the recovery of precious metals and to prevent the creation of hydrogen cyanide. Lime consumption data for these various uses (aluminum and bauxite processing, concentration of copper and gold ores, and unspecified nonferrous uses) are combined to avoid disclosing company proprietary data and are reported in table 3 under metallurgical, nonferrous metallurgy. Lime consumption in nonferrous metallurgy decreased by 21% in 2009. Although specific data are not collected on lime consumption for copper recovery or for gold recovery, both markets likely decreased as a result of a 12% decrease in copper flotation concentrate production and an 8% decrease in gold production compared with those of 2008 (D.L. Edelstein, U.S. Geological Survey, written commun., April 19, 2010; George, 2010b). The decrease in copper flotation concentrate production followed significant revisions to mine plans by several copper producers, including the closure of a mine opened during 2008. Domestic consumption of refined copper trended lower owing to weaker housing and automotive demand, and several brass mills closed during the year (Edelstein, 2010). The decrease in U.S. gold output was primarily the result of reduced production from several gold mines in Nevada and the closure of one mine in Montana and one in Nevada. These decreases were partially offset by increases in production from one new gold mine in Washington and increases from several mines in Nevada (George, 2010a).

Environmental remediation uses of lime in mining include treatment of the tailings that result from the recovery of precious metals, such as gold and silver. These tailings may contain elevated levels of cyanides, and lime is used to recover cyanides in such treatment processes as alkaline chlorination, Caro's acid (H_2SO_5), Cyanisorb™, and sulfur dioxide/air.

Lime is used, generally in conjunction with soda ash, for softening municipal and plant process water. This precipitation process removes bivalent soluble calcium and magnesium cations (and to a lesser extent, ferrous iron, manganese, strontium, and zinc) that contribute to the hardness of water. This process also reduces carbonate alkalinity and total dissolved solids. Lime consumption for drinking water treatment increased slightly compared with that of 2008.

In sewage treatment, the traditional role of lime is to control pH in the sludge digester, which removes dissolved and suspended solids that contain phosphates and nitrogen compounds. Lime also aids in clarification and in destroying harmful bacteria. The leading use in sewage treatment is to stabilize the resulting sewage sludge. Sewage sludge stabilization, also called biosolids stabilization, reduces odors, pathogens, and putrescibility of the solids. Lime stabilization involves mixing quicklime with the sludge to raise the temperature and pH of the sludge to minimum levels for a specified period of time. In 2009, lime consumption for all sludge treatment decreased by about 28% compared with that of 2008.

In flue gas desulfurization (FGD) systems serving coal-fired powerplants, incinerators (most are waste-to-energy powerplants), and industrial plants, lime is injected into the flue gas to remove acidic gases, particularly sulfur dioxide (SO_2) and hydrochloric acid (HCl). It also may be used to stabilize the resulting sludge before disposal. Many FGD systems at utility powerplants are now designed to produce byproduct gypsum from the SO_2 emissions. This byproduct material is suitable for use in manufacturing gypsum wallboard, as an additive in portland cement, and as a soil amendment in agriculture. Hydrated lime may be used in another FGD-related market—to control sulfur trioxide (SO_3) emissions from selective catalytic reduction (SCR) systems installed at powerplants to control emissions of nitrogen oxides (NO_x). Utility powerplants were by far the largest consumers of lime for FGD and accounted for 93% of the total FGD market in 2009. Incinerators, industrial boilers, and other FGD uses accounted for the remaining 7%. In 2009, consumption decreased in all FGD markets—utility powerplants decreased by 14%, incinerators decreased by 8%, and the combined industrial boiler and other FGD markets decreased by 62% compared with those of 2008. Despite these overall decreases, the specific use of hydrated lime for FGD at utility powerplants actually increased by 16%, reflecting the growing use of hydrated lime to treat SO_3 emissions from SCR systems.

Lime is used by the pulp and paper industry in the basic Kraft pulping process where wood chips and an aqueous solution (called liquor) of sodium hydroxide and sodium sulfide are heated in a digester. The cooked wood chips (pulp) are discharged under pressure along with the spent liquor. The pulp is screened, washed, and sent directly either to the paper machine or to the bleaching plant. Lime is sometimes used to produce calcium hypochlorite bleach for bleaching the paper pulp. The spent liquor is processed through a recovery furnace where dissolved organics are burned to recover waste heat, sodium sulfide, and sodium carbonate. The recovered sodium sulfide and sodium carbonate are diluted with water and then treated with slaked lime to recausticize the sodium carbonate into sodium hydroxide (caustic soda) for reuse. The byproduct calcium carbonate is recalcined in a lime kiln to recover lime for reuse. The paper industry also uses lime as a coagulant aid in the clarification of plant process water. In 2009, consumption for pulp and paper production decreased by 6% compared with that of 2008.

Lime is used to make precipitated calcium carbonate (PCC), a specialty filler used in premium-quality coated and uncoated papers, paint, and plastics. The most common PCC production process used in the United States is the carbonation process. CO_2 is bubbled through milk-of-lime to form a precipitate of calcium carbonate and water. The reaction conditions determine the size and shape of the resulting PCC crystals. Lime used for PCC production decreased by nearly 15% compared with that of 2008.

The chemical industry uses lime in the manufacture of alkalis. Quicklime is combined with coke to produce calcium carbide, which is used to make acetylene and calcium cyanide. Lime is used to make calcium hypochlorite, citric acid, petrochemicals, and other chemicals.

In sugar refining, milk-of-lime is used to raise the pH of the product stream, precipitating colloidal impurities. The lime itself is then removed by reaction with CO_2 to precipitate calcium carbonate.

In road paving, hydrated lime is used in hot mix asphalt to act as an antistripping agent. Stripping is generally defined as a loss of adhesion between the aggregate surface and the asphalt cement binder in the presence of moisture. Lime also is used in cold in-place recycling for the rehabilitation of distressed asphalt pavements. Existing asphalt pavement is pulverized using a milling machine, and a hot lime slurry is added along with asphalt emulsion. The cold recycled mix is placed and compacted by conventional paving equipment, which produces a smooth base course for the new asphalt surface. In 2009, sales of lime for use in asphalt increased by 12% compared with those for 2008, but the 281,000 t sold was still 20% below the quantity sold in 2007.

In construction, hydrated lime and quicklime are used to stabilize fine-grained soils in place of materials that are employed as subbases, such as hydraulic clay fills or otherwise poor-quality clay and silty materials obtained from cuts or borrow pits. Lime also is used in base stabilization, which includes upgrading the strength and consistency properties of

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In road paving, hydrated lime is used in hot mix asphalt to act as an antistripping agent. Stripping is generally defined as a loss of adhesion between the aggregate surface and the asphalt cement binder in the presence of moisture. Lime also is used in cold in-place recycling for the rehabilitation of distressed asphalt pavements. Existing asphalt pavement is pulverized using a milling machine, and a hot lime slurry is added along with asphalt emulsion. The cold recycled mix is placed and compacted by conventional paving equipment, which produces a smooth base course for the new asphalt surface. In 2009, sales of lime for use in asphalt increased by 12% compared with those for 2008, but the 281,000 t sold was still 20% below the quantity sold in 2007.

In construction, hydrated lime and quicklime are used to stabilize fine-grained soils in place of materials that are employed as subbases, such as hydraulic clay fills or otherwise poor-quality clay and silty materials obtained from cuts or borrow pits. Lime also is used in base stabilization, which includes upgrading the strength and consistency properties of aggregates that may be judged unusable or marginal without stabilization. Common applications for lime stabilization included the construction of airfields, building foundations, earthen dams, parking areas, and roads.

Lime sales for soil stabilization tend to be cyclical, especially in large market areas, such as Texas. There is competition between lime, cement, fly ash, cement kiln dust, and other additives (liquid enzymes, for example). Choices made by consumers can depend on availability, price, contract specifications, soil chemistry, and State and Federal funding in the case of highway construction projects. In 2009, the soil stabilization market was adversely affected by the severe economic downturn and by reduced highway spending levels in major markets. The American Recovery and Reinvestment Act of 2009 was signed into law in February 2009. It allocated nearly $50 billion for transportation, but only $26.6 billion of that was for the repair or construction of highways or bridges. By the end of 2009, the Federal Highway Administration had authorized 10,000 projects (of which about 6,100 were underway) in all States and territories for a total of $22.4 billion. This represented 84% of total funds available to States (U.S. Department of Transportation, 2010). In the case of Texas, the majority of funds were directed toward bridge construction and other projects that did not require soil stabilization. Total U.S. lime sales for soil stabilization decreased by nearly 40% (or 557,000 t) compared with those for 2008, and the decrease in sales from Texas lime plants accounted for 53% of the nationwide decrease.

Hydrated lime is used in the traditional building sector in mortars, plaster, and stucco. Standard cement mortars that include lime exhibit superior workability balanced with appropriate compressive strength, as well as low water permeability and superior bond strength. Lime is a major constituent in exterior and interior stuccos and plasters, enhancing the strength, durability, and workability of these finishes. A small amount of hydrated lime also is used in the renovation of old structures built with lime mortars, which was standard before the development of portland cement mortars. Modern portland cement mortars are incompatible with old lime mortars. Hydrated lime also is used to make synthetic hydraulic lime, which is produced by blending powdered hydrated lime with pulverized pozzolanic or hydraulic materials.

The U.S. Census Bureau collects data on construction spending for residential construction and 16 categories of nonresidential construction. Although lime may be used in some types of nonresidential construction, most is used in residential construction, and the annual value of residential construction decreased by 27% compared with that of 2008 (U.S. Census Bureau, 2010). Nearly all lime sold for traditional building uses is in the form of hydrate; in 2009, sales of hydrated lime for traditional building uses decreased by 30% compared with those of 2008. Most of the lime (87% in 2009) sold for building uses was produced at a handful of plants located in Nevada, Ohio, Texas, and Wisconsin.

Dead-burned dolomite, also called refractory lime, is used as a component in tar-bonded refractory brick or monolithics manufactured for use in BOF. Refractory brick also is used in the lining of many treatment and casting ladles, in argon oxygen decarburization and vacuum oxygen decarburization converters, in electric arc furnaces (EAF), and in continuous steel casting. Although the data reported in this chapter were rounded to one significant figure to avoid disclosing company proprietary data, the production of dead-burned dolomite decreased compared with that of 2008. Magnesita Refractories Co. (formerly LWB Refractories Co.) at its York, PA, plant and Carmeuse at its Millersville, OH, plant were the only significant producers. Although dead-burned dolomite is the primary form of lime used in refractories, hydrated lime may be used to produce silica refractory brick used to line industrial furnaces.

Prices

The average values per ton for the various types of lime are listed in table 5. All value data for lime are reported by type of lime produced—high-calcium quicklime, high-calcium hydrate, dolomitic quicklime, and dolomitic hydrate. To avoid revealing company proprietary data, value data for dead-burned dolomite are included with the averages for all types.

Prices continued to increase, with quicklime prices increasing about $11 per metric ton and hydrate prices increasing about $19 per ton, although the latter may also reflect a shift in product mix. Large price increases that went into effect beginning in 2009 were announced by some of the leading lime companies in late 2008. It appears that, despite the decrease in sales, lime producers were able to push through higher prices. Fuel surcharges (not included in the 2008 prices reported in table 5) were applied by many of the lime companies in early 2008 but were no longer in effect in 2009, when fuel prices decreased dramatically. In recent years, lime companies have reported that they were unable to keep up with rising production costs, and the large 2009 price increases were lime company efforts to reestablish operating margins.

The following average values are compared with those of 2008. The average for all types of lime sold increased to $103.80 per ton ($94.20 per short ton) or a 13% increase. The average value for high-calcium quicklime sold increased by nearly 12% to $98.20 per ton ($89.10 per short ton), and the average value for dolomitic quicklime sold increased by nearly 14% to $111.90 per ton ($101.50 per short ton). The average value of high-calcium hydrate increased by nearly 20%, and the average value of dolomitic hydrate increased by more than 9%.

Foreign Trade

The United States exported and imported quicklime, hydrated lime (slaked lime), hydraulic lime, and calcined dolomite (dolomitic lime). Combined exports of lime were 108,000 t (119,000 short tons) valued at $18.5 million. About 89% of exports went to Canada, with the remaining going to Mexico (9%), and other countries (2%) (table 6).

Combined imports of lime were 422,000 t (465,000 short tons) valued at $53.2 million, with 85% from Canada, 14% from Mexico, and 1% from other countries (table 7). Canada was the primary source of quicklime (high-calcium and dolomitic) imports and accounted for 89% of the total, but imports of hydrated lime were more evenly split, with Canada and Mexico accounting for 56% and 42%, respectively.

No tariffs are placed on imports of hydraulic lime, quicklime, and slaked lime from countries with normal trade relations (NTR) with the United States. A 3% ad valorem tariff is placed on imports of calcined dolomite from NTR countries.

World Review

Lime is not a commodity that is traded internationally. Traditionally, lime has been a low-value bulk product that could not be shipped long distances and compete with lime produced locally. Most countries have limestone or dolomite deposits and as a result are able to manufacture lime for their own consumption. There may be some trade between countries on a regional basis where distances are not too great, such as in the European Union, or to supply lime products of quality not locally available.

With the exception of some industrialized nations, accurate lime production data for individual countries are difficult to obtain. Besides production by large commercial lime companies, lime is produced by small-scale manufacturers operating simple kilns to supply individual villages and by industries producing lime for captive consumption. These variations and the frequent confusion with limestone data make accurate reporting extremely difficult and certainly incomplete. In some cases, lime sales data have been used to estimate country production figures. Beginning in 2006, major revisions were made to the estimates for China based on new information. New estimates were made for India's lime production covering the period 2005–09, based on steel production and other market assumptions (table 8).

Outlook

Through the early part of 2010, the U.S. economy appeared to be showing signs of recovery. There were, however, existing factors that could derail the U.S. economic recovery by adversely affecting financial markets. These included debt problems in some European Union countries, the U.S. Federal deficit, and the large oil spill in the Gulf of Mexico that could negatively affect various industries in the region. A recovering U.S. economy would likely bolster lime sales in most markets, although construction may lag any recovery.

In 2009, lime's largest market, steelmaking and related uses, recorded a decrease in consumption of 35% compared with that in 2008. This market segment normally accounts for about 30% of lime consumption, but in 2009, that percentage dropped to 24%. U.S. raw steel production for the year to date through May was around 32.6 Mt (67% higher than the same period in 2009), which projected through yearend would equate to an annual production of 78 Mt (American Iron and Steel Institute, 2010). This compares with domestic raw steel production of 58.0 Mt for 2009, 91.9 Mt for 2008, 98.1 Mt for 2007, and 98.2 Mt for 2006. If 2010 trend continues, then this would likely result in an increase in lime consumption for steelmaking to 5.2 Mt from 3.8 Mt in 2009.

FGD is the second leading end-use market for lime. With the economy beginning to recover, electric power generation rates are expected to increase compared with those of 2009. Coal accounts for nearly 50% of net electrical generation on an annual basis, and it is these coal-fired powerplants that use the majority of lime consumed for FGD. In 2010, this market is expected to recover some of the lost sales experienced in 2009.

Longer term growth is still expected in the FGD and related markets as a result of EPA's clean air interstate rule (CAIR) or its replacement. The CAIR was designed originally to permanently cap emissions of SO_2 and NO_x in 28 Eastern States and the District of Columbia and would reduce these emissions through a cap-and-trade system. The original CAIR was vacated in July 2008 by the Circuit Court for the District of Columbia Court of Appeals, finding that it had "more than several fatal flaws." In December 2008, the CAIR was revived when, upon rehearing, the court agreed with the EPA that the effect of vacating the CAIR was detrimental to the environment. The court partly reversed its original decision by remanding the CAIR to the agency for revision and reinstated the CAIR until a new rule is ready to replace it. The EPA informed the court that development and finalization of a replacement rule could take about 2 years (Demase and others, 2009).

FGD systems that use limestone already dominate the utility powerplant market, and lime price increases in recent years have effectively taken lime out of consideration for use in large new wet FGD systems at powerplants. However, opportunities continue to exist for dry lime FGD systems on smaller utility and industrial boiler units and for the use of hydrated lime to treat SO_3 wastes from SCR systems that control NO_x emissions.

In conclusion, driven primarily by the recovering steel market, domestic lime output in 2010 may increase by 10% to 15% to between 17.4 and 18.2 Mt. It will likely, however, take years for lime demand to recover to the levels achieved prior to the recession, considering that it took more than a decade for lime consumption to climb back to previous levels after the major 1981–82 recession.

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TABLE 1

SALIENT LIME STATISTICS[1, 2]

		2005	2006	2007	2008	2009
United States[3]						
Number of plants[4]		94	91	89	90 r	83
Sold or used by producers:						
Quicklime:						
High-calcium	thousand metric tons	14,100	15,000	14,700	14,900	11,800
Dolomitic	do.	2,990	2,950	2,700	2,310	1,830
Total	do.	17,100	18,000	17,400	17,200	13,700
Hydrated lime:						
High-calcium	do.	2,220	2,370	2,240	2,070	1,690
Dolomitic	do.	474	409	352	358	261
Total	do.	2,700	2,780	2,590	2,420	1,950
Dead-burned dolomite[5]	do.	200	200	200	200	200
Grand total:						
Quantity	do.	20,000	21,000	20,200	19,900	15,800
Value[6]	thousand dollars	1,500,000	1,700,000	1,760,000	1,840,000	1,660,000
Average value	dollars per metric ton	75.00	81.20	87.10	92.40	105.00
Lime sold by producers:						
Quicklime	thousand metric tons	15,900	16,600	16,100	16,000	12,600
Hydrated lime	do.	2,700	2,780	2,590	2,420	1,950
Total	do.	18,600	19,400	18,700	18,400	14,500
Value	thousand dollars	1,370,000	1,560,000	1,600,000	1,690,000	1,510,000
Lime used by producers	thousand metric tons	1,490	1,620	1,530	1,470	1,260
Value	thousand dollars	129,000	144,000	155,000	149,000	150,000
Exports:[7]						
Quantity	do.	133	116	144	174	108
Value	do.	17,500	19,200	24,800	27,100	18,500
Imports for consumption:[7]						
Quantity	thousand metric tons	310	298	375	307	422
Value	thousand dollars	33,100	36,300	49,600	39,400	53,200
Consumption, apparent[8]	thousand metric tons	20,200	21,200	20,400	20,000	16,100
World, production	do.	270,000 r	284,000 r	296,000 r	307,000 r	299,000 e

e Estimated. r Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] To convert metric tons to short tons, multiply metric tons by 1.102.

[3] Excludes regenerated lime; includes Puerto Rico.

[4] Includes most producer-owned hydrating plants not located at lime plants.

[5] Data are rounded to no more than one significant digit to avoid disclosing company proprietary data.

[6] Selling value, free on board plant.

[7] Source: U.S. Census Bureau.

[8] Defined as sold or used plus imports minus exports.

TABLE 2

LIME SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1, 2]

State	Plants[3]	Hydrated (thousand metric tons)[4]	Quicklime[5] (thousand metric tons)[4]	Total (thousand metric tons)[4]	Value (thousands)
2008:					
Alabama	6 [r]	108	2,210	2,320	$239,000
Arizona, Colorado, Montana, Nevada, New Mexico, Utah, Wyoming	16	241	2,610	2,850	254,000
California, Idaho, Oregon, Washington	9	54	259	314	37,100
Illinois, Indiana, Missouri	6 [r]	453	3,380 [r]	3,830 [r]	337,000 [r]
Iowa, Nebraska, South Dakota	3	41	302	343	31,600
Kentucky, Tennessee, West Virginia	6 [r]	136	2,670 [r]	2,810 [r]	229,000 [r]
Ohio	6	117	1,550	1,670	166,000
Pennsylvania	4	186	942	1,130	126,000
Texas	5	680	819	1,500	128,000
Wisconsin	4	162	690	852	71,500
Other[6]	25 [r]	246	2,000	2,240	217,000
Total	90 [r]	2,420	17,400	19,900	1,840,000
2009:					
Alabama	6	114	1,840	1,960	225,000
Arizona, Colorado, Montana, Nevada, New Mexico, Utah, Wyoming	13	195	2,310	2,500	256,000
California, Idaho, Oregon, Washington	9	47	119	166	28,200
Illinois, Indiana, Missouri	4	371	2,650	3,020	306,000
Iowa, Nebraska, South Dakota	3	41	257	298	29,500
Kentucky, Tennessee, West Virginia	6	102	2,110	2,220	197,000
Ohio	5	85	1,040	1,130	129,000
Pennsylvania	4	167	818	985	126,000
Texas	5	453	590	1,040	105,000
Wisconsin	4	145	606	751	70,100
Other[6]	24	232	1,470	1,710	184,000
Total	83	1,950	13,800	15,800	1,660,000

[r] Revised.

[1] Excludes regenerated lime.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Includes most producer-owned hydrating plants not located at lime plants.

[4] To convert metric tons to short tons, multiply metric tons by 1.102.

[5] Includes dead-burned dolomite.

[6] Includes Arkansas, Florida, Georgia, Louisiana, Massachusetts, Michigan, Minnesota, North Dakota, Oklahoma, Puerto Rico, and Virginia.

TABLE 3
LIME SOLD AND USED BY PRODUCERS IN THE UNITED STATES, BY USE[1, 2]

(Thousand metric tons[3] and thousand dollars)

Use	2008		2009	
	Quantity[4]	Value[5]	Quantity[4]	Value[5]
Chemical and industrial:				
Fertilizer, aglime and fertilizer	43	3,940	52	6,770
Glass	206	19,000	106	10,900
Paper and pulp	865	79,900	814	83,900
Precipitated calcium carbonate	1,110	102,000	944	109,000
Sugar refining	675	62,400	733	74,600
Other chemical and industrial[6]	1,500	139,000	1,240	143,000
Total	4,400	406,000	3,890	428,000
Metallurgical:				
Steel and iron:				
Basic oxygen furnaces	2,590	239,000	1,600	176,000
Electric arc furnaces	2,840	263,000	1,920	207,000
Other steel and iron	431	39,800	302	28,800
Total	5,860	542,000	3,810	411,000
Nonferrous metallurgy[7]	1,370	127,000	1,080	107,000
Total metallurgical	7,230	668,000	4,900	519,000
Construction:				
Asphalt	250	23,100	281	34,500
Building uses	362	33,500	254	32,200
Soil stabilization	1,410	130,000	848	82,700
Other construction	53	4,930	39	4,300
Total	2,070	191,000	1,420	154,000
Environmental:				
Flue gas desulfurization (FGD):				
Utility powerplants	3,630	335,000	3,110	274,000
Incinerators	235	21,700	216	25,100
Industrial boilers and other FGD	77	7,090	29	3,650
Total	3,940	364,000	3,360	303,000
Sludge treatment:				
Sewage	118	10,900	86	9,450
Other, industrial and hazardous	113	10,500	81	8,500
Total	231	21,300	167	18,000
Water treatment:				
Acid-mine drainage	90	8,290	82	10,500
Drinking water	945	87,300	963	99,600
Wastewater	597	55,200	630	74,400
Total	1,630	151,000	1,680	184,000
Other environmental	143	13,300	184	20,100
Total environmental	5,950	550,000	5,390	525,000
Refractories (dead-burned dolomite)	200 [8]	19,700 [9]	200 [8]	30,000 [8]
Grand total	19,900	1,840,000	15,800	1,980,000

[1] Excludes regenerated lime. Includes Puerto Rico.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] To convert metric tons to short tons, multiply metric tons by 1.102.

[4] Quantity includes lime sold and used, where "used" denotes lime produced for internal company use for basic oxygen furnaces, magnesia, paper and pulp, precipitated calcium carbonate, refractories, and sugar refining.

[5] The U.S. Geological Survey does not collect value data by end use; the values shown are mainly derived from average lime values.

[6] May include alkalis, calcium carbide and cyanamide, calcium hypochlorite, citric acid, food (animal or human), oil and grease, oil well drilling, petrochemicals, tanning, and other uses. Magnesia is included here to avoid disclosing proprietary data.

[7] Includes aluminum and bauxite, magnesium, ore concentration (copper and gold) and other nonferrous uses.

[8] Data are rounded to no more than one significant digit to avoid disclosing company proprietary data.

[9] Value was derived from an average lime value per metric ton rather than a specific average value per metric ton of dead-burned dolomite.

TABLE 4
HYDRATED LIME SOLD OR USED IN THE UNITED STATES, BY END USE[1, 2]

(Thousand metric tons[3] and thousand dollars)

Use	2008 Quantity[4]	2008 Value[5]	2009 Quantity[4]	2009 Value[5]
Chemical and industrial	571	61,200	482	66,700
Construction:				
Asphalt	215	23,100	251	31,700
Building uses	354	38,000	248	31,600
Soil stabilization	564	60,400	310	30,400
Other construction	11	1,180	12	1,420
Total	1,140	123,000	821	95,100
Environmental:				
Flue gas desulfurization (FGD):				
Utility powerplants	97	10,400	113	14,800
Incinerators	31	3,330	31	4,070
Industrial boilers and other FGD	36	3,840	19	2,610
Total	164	17,600	163	21,500
Sludge treatment:				
Sewage	30	3,260	16	2,270
Other sludge treatment	44	4,690	28	3,830
Total	74	7,940	44	6,100
Water treatment:				
Acid-mine drainage	69	7,350	46	6,320
Drinking water	161	17,200	138	18,000
Wastewater	160	17,200	193	24,200
Total	390	41,800	377	48,500
Other environmental	42	4,490	38	4,790
Metallurgy	40	4,340	30	4,010
Grand total	2,420	260,000	1,950	247,000

[1] Excludes regenerated lime. Includes Puerto Rico.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] To convert metric tons to short tons, multiply metric tons by 1.102.

[4] Quantity includes hydrated lime sold and used, where "used" denotes lime produced for internal company use in building, chemical and industrial, and metallurgical sectors.

[5] The U.S. Geological Survey does not collect value data by end use; the values shown are mainly derived from an average value per metric ton of hydrated lime.

TABLE 5
LIME PRICES[1]

Type	2008 Dollars per metric ton	2008 Dollars per short ton[2]	2009 Dollars per metric ton	2009 Dollars per short ton[2]
Sold and used:				
Quicklime	89.90	81.60	102.00	92.50
Hydrate	107.20	97.30	126.40	114.70
Average all types[3]	92.40	83.90	105.00	95.20
Sold:				
High-calcium quicklime	87.80	79.70	98.20	89.10
Dolomitic quicklime	98.50	89.30	111.90	101.50
Average quicklime	89.20	80.90	100.00	90.70
High-calcium hydrate	103.90	94.30	124.60	113.00
Dolomitic hydrate	126.40	114.70	138.20	125.30
Average hydrate	107.20	97.30	126.40	114.70
Average all types[3]	91.70	83.20	103.80	94.20

[1] Average value per ton, on a free-on-board-plant basis, including cost of containers.

[2] Unit values in metric and short tons were rounded independently.

[3] Includes dead-burned dolomite.

TABLE 6
U.S. EXPORTS OF LIME, BY TYPE[1]

(Metric tons and dollars)

Type	2008		2009	
	Quantity[2]	Value[3]	Quantity[2]	Value[3]
Calcined dolomite:				
Canada	65,000	$10,100,000 [r]	43,100	$7,200,000
Japan	567	566,000	--	--
Other	303 [r]	101,000 [r]	370	119,000
Total	65,800	10,700,000	43,400	7,320,000
Hydraulic lime:				
Austria	--	--	667	120,000
Bahamas, The	307	60,000	209	56,900
Canada	4,400	917,000	4,880	916,000
Saudi Arabia	265	47,800	1	6,730
Other	298 [r]	304,000 [r]	337	145000
Total	5,270	1,330,000	6,090	1,240,000
Quicklime:				
Canada	81,800	10,500,000	34,200	5,610,000
Costa Rica	80	24,800	477	150,000
Mexico	5,490	536,000	9,710	1,030,000
Other	515 [r]	923,000 [r]	151	319,000
Total	87,900	12,000,000	44,500	7,100,000
Slaked lime, hydrate:				
Angola	857	428,000	18	4,980
Canada	13,700	2,340,000	13,600	2,620,000
Nigeria	662	179,000	449	122,000
Other	133 [r]	74,200 [r]	42	72,600
Total	15,400	3,020,000	14,100	2,820,000
Grand total	174,000	27,100,000	108,000	18,500,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] To convert metric tons to short tons, multiply metric tons by 1.102.

[3] Declared free alongside ship valuation.

Source: U.S. Census Bureau.

TABLE 7

U.S. IMPORTS FOR CONSUMPTION OF LIME, BY TYPE[1]

(Metric tons and dollars)

	2008		2009	
Type	Quantity[2]	Value[3]	Quantity[2]	Value[3]
Calcined dolomite:				
Canada	17,600	$2,130,000	7,740	$1,200,000
Mexico	--	--	33,000	2,520,000
Other	86	70,100	8	13,800
Total	17,700	2,200,000	40,700	3,730,000
Hydraulic lime:				
Canada	--	--	53	10,900
France	194	132,000	181	113,000
Mexico	286	32,700	61	7,520
Netherlands	40	31,300	72	25,500
Other	69 r	63,400 r	56	27,800
Total	589 r	260,000	423	185,000
Quicklime:				
Canada	238,000	29,700,000	322,000	40,100,000
Mexico	5,950	429,000	5,070	553,000
Other	1,730	386,000	1,180	682,000
Total	245,000	30,500,000	329,000	41,300,000
Slaked lime, hydrate:				
Canada	19,000	2,340,000	29,200	3,680,000
Mexico	23,400	3,100,000	22,100	3,210,000
Other	717 r	980,000 r	1,100	1,070,000
Total	43,200	6,420,000	52,300	7,960,000
Grand total	307,000	39,400,000	422,000	53,200,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] To convert metric tons to short tons, multiply metric tons by 1.102.

[3] Declared cost, insurance, and freight valuation.

Source: U.S. Census Bureau.

TABLE 8
QUICKLIME AND HYDRATED LIME, INCLUDING DEAD-BURNED DOLOMITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Australia[e]	1,500	1,600	1,600	2,200[r]	2,000
Austria	460[r]	465[r]	491[r]	612[r]	500
Belgium[e, 4]	2,300	2,400	2,400[r]	2,300[r]	2,000
Bosnia and Herzegovina	186	218	237	216	210
Brazil	6,500	7,057	7,393[r]	7,400[r, e]	7,450
Bulgaria[4]	1,352	1,409	1,443[r]	1,500[e]	1,500
Canada	2,289	2,185	2,134	2,069	1,601[5]
Chile[e]	600	660	720[r]	690[r]	700
China[e]	150,000	160,000	170,000	180,000	185,000
Croatia[e, 4]	250[r]	260[r, 5]	572[r, 5]	600[r]	600
Czech Republic	1,211	1,218	1,277[r]	1,200[r, e]	1,200
Egypt[e]	800	800	1,000[r, 5]	1,000[r, 5]	1,000
Finland[e]	430	430	517[r, 5]	482[r, 5]	500
France[e, 4]	3,300	4,000	4,000	4,000	3,500
Germany	6,823	7,119	7,218	7,313[r]	6,000
Hungary[e]	500	500	500	500	500
India[e]	11,000[r]	12,000[r]	12,000[r]	13,000[r]	13,000
Iran[e]	2,500	2,600	2,600	2,700	2,700
Israel	166	158	282	481	480
Italy[e, 6]	6,300	5,900	6,000	6,000	6,000
Jamaica	270	304	277	313	300
Japan, quicklime only	8,879	9,014	9,359	9,528[r]	8,400
Kazakhstan	702	769	828	885	804[5]
Korea, Republic of[e]	3,600[5]	3,700[r]	3,900[r]	4,000[r]	3,600
Malaysia[e]	700	800	1,300	900	800
Mexico[e, 4]	6,500	6,500	6,200[r]	6,000[r]	5,500
Peru	215	216	215[e]	215[e]	216[p, 5]
Poland	1,749	1,936	2,143	1,952[r]	1,950
Romania[e]	1,791[5]	1,942[5]	2,000[r]	2,000[r]	2,000
Russia[e]	8,200	8,200	8,200	8,200	7,000
Saudi Arabia[e]	360	360	400	400	400
Serbia	400[7]	377	320	320	320
Slovakia	946	1,104	1,123	1,082[r]	1,080
Slovenia[e]	1,500	1,500	1,500	1,500	NA
South Africa, burnt lime sales	1,417	1,585	1,599	1,593	1,375[5]
Spain[e, 4]	1,818[5]	2,000	2,000	2,000	2,000
Sweden[e]	740[r]	750[r]	780[r]	750[r]	600
Taiwan[e]	444[5]	450	470	450	450
Thailand[e]	800	800	800	800	750
Tunisia	424	401	395	369[r]	370
Turkey[e, 4]	3,600[r]	3,800[r]	4,000[r]	4,000[r]	3,800
United Kingdom[e]	2,000	2,000	2,000	1,500	1,500
United States, including Puerto Rico	20,000	21,000	20,200	19,900	15,800[5]
Venezuela[e]	400	400	400	400	400
Vietnam	1,737	1,592[r]	1,438[r]	1,679[r]	1,700
Zambia[e]	180	180	190	150	150
Other[e]	1,760[r]	1,710[r]	1,690[r]	1,750[r]	1,710
Total	270,000[r]	284,000[r]	296,000[r]	307,000[r]	299,000

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through March 29, 2010.

[3] In addition to the countries listed, Argentina, Chad, Iraq, Nigeria, Pakistan, Syria, and several other nations produce lime, but output data are not reported; available general information is inadequate to formulate reliable estimates of output levels.

[4] Production estimate based on sales only; data may be incomplete.

TABLE 8—Continued

QUICKLIME AND HYDRATED LIME, INCLUDING DEAD-BURNED DOLOMITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

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[5] Reported figure.

[6] Includes hydraulic lime.

[7] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

LITHIUM

By Brian W. Jaskula

Domestic survey data and tables were prepared by Susan M. Weaver, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2009, lithium consumption in the United States was estimated to be 1,300 metric tons (t) of contained lithium, 43% less than the consumption in 2008 and 46% less than in 2007. Decreased U.S. consumption was primarily the result of deteriorating market conditions for lithium-based products in the United States owing to the worldwide economic downturn. Consumers may have run down their existing inventory of lithium compounds in 2009 instead of purchasing new. Therefore, actual lithium consumption may have been greater than the 1,300 t reported, but no data were available to support a higher estimate. Lithium carbonate consumed in industrial applications and used as a raw material for other lithium compounds in the United States was produced at a domestic brine operation in Nevada and imported from Argentina and Chile.

Lithium has historically been mined from two distinct sources—continental brines and hard rock ore. Chile was the world's leading producer of lithium carbonate with production from two lithium brine operations on the Salar de Atacama in the Andes Mountains. Concentrated brines were processed at two lithium carbonate plants in Antofagasta. In the United States, production continued at a lithium brine operation with an associated lithium carbonate plant in Silver Peak, NV. Lithium carbonate and lithium chloride also were produced from brines from the Salar del Hombre Muerto in the Andes Mountains in Argentina. In China, lithium carbonate was produced from brines from the Zabayu Salt Lake in western Tibet and from the Dongtai and Xitai Salt Lakes in Qinghai Province.

Australia was, by far, the leading producer of lithium mineral concentrates, and Brazil, Canada, China, Portugal, and Zimbabwe also produced significant quantities. China was the only country that produced large quantities of lithium carbonate from concentrates, mostly from imported Australian spodumene. A large percentage of the lithium carbonate produced in South America was exported to the United States for consumption in industrial applications and as feed material for the production of downstream lithium compounds, such as lithium hydroxide monohydrate, lithium metal, and organic lithium compounds.

Despite the reduced consumption of lithium in 2009, worldwide lithium resource exploration (led predominantly by Australian and Canadian startup companies) more than doubled compared with that of 2008. The continental brine and clay resources of Nevada were a major focus of this exploration in the United States, as were the pegmatite and oil brine resources of Canada, and the pegmatite resources of Australia. Additionally, Argentina, Bolivia, and Chile saw significant exploration of their continental brines.

Legislation and Government Programs

Under the authority of the American Recovery and Reinvestment Act of 2009 (ARRA; Public Law 111-5), the U.S. Department of Energy (DOE) awarded $1.5 billion in grants to accelerate the development of U.S. manufacturing and production capacity of batteries for electric-drive vehicles and battery recycling. The grants represent the largest single investment in advanced battery technology for hybrid and electric-drive vehicles ever made, and lithium-ion battery technology figured prominently in the awards (U.S. Department of Energy, 2009b). ARRA also funded grants for Smart Grid demonstration and energy storage projects that included large-scale lithium-ion batteries for energy storage (U.S. Department of Energy, 2009c).

As part of its Advanced Technology Vehicles Manufacturing Incentive Program, the DOE loaned Nissan North America, Inc. $1.6 billion to convert its Smyrna, TN, plant to produce electric cars and lithium-ion battery packs. Tesla Motors received a $465 million loan from the DOE to build an automobile manufacturing facility in southern California and a facility in Palo Alto, CA, to assemble lithium-ion battery packs, electric motors, and electric-drive trains (U.S. Department of Energy, 2009a). Fisker Automotive, Inc. received $528 million for the development and production of two lines of lithium-ion battery powered plug-in hybrid electric vehicles (U.S. Department of Energy, 2009d).

Recycling

To begin the process of ramping up their respective lithium battery recycling infrastructures, the Governments of the United States and Germany invested in a private energy company in 2009. As part of ARRA, the DOE awarded $9.5 million to California-based battery recycler Toxco, Inc. to construct the first U.S. recycling facility for lithium-ion vehicle batteries. The company has recycled lithium metal and lithium-ion batteries since 1992 at its Canadian facility in British Columbia. Toxco planned to expand its existing facility in Lancaster, OH, that currently recycles the nickel-metal hydride and lead-acid batteries from hybrid-electric vehicles (Hamilton, 2009). In Germany, Chemetall GmbH was awarded $8.4 million by the Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety to set up a pilot plant at the company's Langelsheim facility for the recycling of lithium-ion batteries (Rockwood Holdings, Inc., 2010, p. 5, 17). Japan's Nippon Mining & Metals Co., Ltd. announced plans to open a commercial-scale plant to recycle lithium-ion batteries. The commercial operation was planned to open in 2011 after the completion of a pilot plant demonstration (Platts Metals Week, 2009).

Production

The U.S. Geological Survey (USGS) collects domestic production data for lithium from a voluntary canvass of U.S.

operations. The only U.S. lithium carbonate producer, Chemetall Foote Corp. (a subsidiary of the German company Chemetall, which is owned by Rockwood Holdings, Inc., of Princeton, NJ) responded to the survey, representing 100% of total production. Production and stock data were withheld from publication to avoid disclosing company proprietary data (table 1). It is known, however, that production decreased in 2009 from that of 2008 owing to the worldwide economic downturn.

Chemetall Foote produced lithium carbonate from brines near Silver Peak, NV. The company's other U.S. lithium operations included a lithium hydroxide plant in Silver Peak; a butyllithium plant in New Johnsonville, TN; and facilities for producing downstream lithium compounds in Kings Mountain, NC. Chemetall Foote's subsidiary in Chile, Sociedad Chilena de Litio Ltda., produced lithium carbonate and lithium chloride from a brine deposit.

In August, the DOE awarded Chemetall Foote $28.4 million to expand and upgrade the production of lithium compounds used in batteries at the company's Silver Peak and Kings Mountain processing plants (Rockwood Holdings, Inc., 2010, p. 80).

FMC Corp.'s Lithium Division produced a full range of downstream compounds, lithium metal, and organic lithium compounds at its facilities in Bessemer City, NC, and, until March 2009, Bayport, TX. In response to the weaker market conditions for lithium-based products resulting from the worldwide economic downturn, FMC closed its Bayport butyllithium facility and consolidated all U.S. butyllithium production at its Bessemer City facility (FMC Lithium, 2009). The company met its lithium carbonate and lithium chloride requirements with material produced at its operation in Argentina. In March, the DOE awarded a $3 million grant to FMC's Center for Lithium Energy and Advanced Research to scale up production of a proprietary product known as stabilized lithium metal power used for high-energy Li-ion battery cathodes (Jackson, 2010).

In May and September, American Lithium Minerals, Inc. acquired several lithium brine prospects in Esmeralda County, NV, from GeoXplor Corp., a private Nevada company. The lithium brine prospects were within the Great Basin Province of the southwestern United States. In September, the company announced that a gravity survey and electromagnetic survey would be conducted on one of the prospects to delineate the appropriate drill targets (American Lithium Minerals Inc., 2009a; 2009b).

California-based Simbol Mining Corp. purchased and relocated the assets and intellectual property of Limtech Lithium Industries, Inc., a Canadian lithium processing company which previously sold high-purity lithium carbonate to battery manufacturers in Japan. Simbol planned to use the 500-metric-ton-per-year (t/yr) lithium carbonate processing plant to extract lithium and other high-value mineral commodities used in batteries from geothermal fluids by using a unique reverse osmosis process. If successful, Simbol's geothermal brine process would eliminate the need for solar evaporation, a crucial and lengthy process in more common lithium brine operations (Moores, 2010c).

In February, Rodinia Minerals, Inc. (Vancouver, British Columbia, Canada) acquired 250 unpatented mining claims in Clayton Valley, Esmeralda County, NV, from GeoXplor Corp. The mining claims were adjacent to Chemetall Foote's lithium brine operation. By yearend, Rodinia completed gravity and two-dimensional seismic surveys of the claims and began a three-hole drilling program to test the lithium-bearing aquifers (Rodinia Minerals, Inc., 2009a, b).

In December, Western Lithium Canada Corp. (Vancouver, British Columbia, Canada) completed the drilling process on the second of its five lithium-rich hectorite clay deposits at its Kings Valley, NV, project. The drilling operation, from which core samples would be evaluated in an independent technical and economic assessment in early 2010, was performed to determine if additional years of mine life could be added to the hectorite operation. The second deposit was approximately seven times larger than the first deposit. Based on exploration of the area performed by Chevron Resources, Inc. (a subsidiary of Chevron Corp.) in the 1980s, Western Lithium Canada Corp. estimated that 2 million metric tons (Mt) of contained lithium may be available (Western Lithium Canada Corp., 2009; 2010).

Consumption

Lithium is sold as brines, compounds, metal, or mineral concentrates depending on the end use. Lithium's electrochemical reactivity and other unique properties have resulted in many commercial lithium products. For many years, most lithium compounds and minerals were used in the production of ceramics, glass, and primary aluminum. Growth in lithium battery use and decreased use of lithium in aluminum production has resulted in batteries gaining market share. For 2009, Chilean lithium producer Sociedad Química y Minera de Chile S.A. (SQM) listed the main global markets for lithium products as follows—ceramics and glass, 30%; batteries, 21%; lubricating greases, 10%; air treatment, 5%; metallurgical, 5%; primary aluminum production, 3%; and other uses, 26% (de Solminihac, 2010, p. 11). The "other uses" category represented several smaller end uses that may have included alloys, construction, dyestuffs, industrial bleaching and sanitation, pool chemicals, and specialty inorganics (FMC Corp., 2008). Roskill Information Services Ltd. offered different consumption estimates for 2009 but confirmed that ceramics and glass remained the top global market for lithium. Roskill's estimates were ceramics and glass, 31%; batteries, 23%; lubricating greases, 9%; primary aluminum production, 6%; air treatment, 6%; continuous casting, 4%; rubber and thermoplastics, 4%; pharmaceuticals, 2%; and other uses, 15% (Baylis, 2010, p. 11). Domestic end uses for lithium materials may not directly correspond to worldwide consumption, but the data necessary for making more reliable estimates were not available.

In 2009, the decline in U.S. lithium consumption could be attributed to decreased consumption in most end uses owing to a slowdown in the economy that began in the second half of 2008. If lithium concentrates were included in lithium consumption estimates, the leading use of lithium in the United States likely was in ceramics and glass manufacturing processes. No lithium concentrates, however, were produced in the United States for direct application in ceramics and glass manufacture, and import statistics do not specifically identify lithium ore imports, making it difficult to accurately estimate end uses.

In 2009, most lithium batteries were manufactured in Asia, with 39% of lithium-ion battery production concentrated in Japan, 36% in China, and 20% in the Republic of Korea (Evans, 2009). Lithium's natural properties make it one of the most attractive battery materials of all the elements. In 2008 (the most recent year for which data are available) lithium-ion battery production represented 75% of the total portable rechargeable battery market worldwide, and growth was expected to continue (SBI Reports, 2009). Worldwide, rechargeable lithium batteries powered most cellular telephones and laptop computers, as well as many heavy-duty power tools. Automakers were working on lithium batteries for hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV), and pure electric vehicles (EV).

U.S. primary aluminum production, and lithium consumption in that end use, declined during 2009 because aluminum production was curtailed owing to a significant drop in the price of aluminum in the second half of 2008, which continued throughout 2009 (Bray, 2010).

Additional information concerning other lithium end uses can be found in the lithium chapter of the 2006 U.S. Geological Survey Minerals Yearbook, volume I, Metals and Minerals.

Prices

Customs values for lithium carbonate imports to the United States were used as an indication of the trends in lithium pricing, although they never exactly reflected the producers' prices for lithium carbonate. The average customs unit value for imported lithium carbonate was $4.53 per kilogram, slightly higher than that of 2008. The average unit customs value of lithium hydroxide decreased about 6%. The average unit value of exported lithium carbonate was 19% higher than in 2008 and more than 50% higher than the average unit value of imported carbonate. This suggests that the material exported from the United States was higher quality lithium carbonate than that which was imported.

In September, SQM announced that it would reduce its lithium carbonate and lithium hydroxide prices by 20% for contracts effective January 2010. The company indicated that its lithium carbonate prices, which ranged from $6.20–$6.60 per kilogram in 2009, would be lowered to $5.10–$5.30 per kilogram (Tran, 2010).

At yearend, glass-grade spodumene (5% lithium oxide) was reported to be selling for $363 to $408 per metric ton. Australian spodumene producer Talison Lithium Ltd. (formally Talison Minerals Pty. Ltd.) announced in November that it would increase prices for technical-grade spodumene for contracts effective January 2010. The prices are expected to increase to $380 to $430 per metric ton (Industrial Minerals, 2009b; 2009d).

Foreign Trade

In 2009, total exports of lithium compounds from the United States decreased 35% compared with those of 2008. About 34% of all U.S. exports of lithium compounds went to Japan, while 18% went to Germany, and 13% went to the United Kingdom. The remainder was divided among many other countries (table 2).

Imports of lithium compounds decreased by 40% in 2009 compared with those of 2008. Of the 10,000 t of lithium compounds imported, 61% came from Argentina, 33% from Chile, and the remainder from several other countries (table 3). This was the first year that most lithium imports originated from Argentina, rather than Chile. Lithium concentrates from Australia, Canada, and (or) Zimbabwe may have entered the United States, but because these materials have no unique import code, no import data were available. The United States was the largest importer of lithium carbonate and lithium chloride in the world.

World Review

World lithium production (excluding U.S. production) was estimated to be 18,800 t of lithium contained in minerals and compounds in 2009, a decrease of 27% from that of 2008. Gross weight production figures for lithium carbonate, lithium chloride, and lithium mineral concentrates are listed in table 4. Argentina, Chile, China, and the United States were the leading producers of lithium carbonate. Significant quantities of lithium compounds and concentrates also were produced in Australia, Brazil, Canada, Portugal, and Zimbabwe. Congo (Kinshasa), Namibia, Russia, Rwanda, and South Africa have produced concentrates in the past. Several brine operations were under development in Argentina; spodumene mining operations were under development in Australia, Canada, and Finland; and a jadarite mining operation was under development in Serbia. Pegmatites containing lithium minerals have been identified in Afghanistan, Austria, France, India, Ireland, Mozambique, Spain, Sweden, and Zaire, but economic conditions have not favored development of the deposits. Lithium has been identified in subsurface brines in Bolivia and Israel. Companies in France, Germany, Japan, the Republic of Korea, Russia, Taiwan, and the United Kingdom produced downstream lithium compounds from imported lithium carbonate.

World lithium consumption was reported by SQM to be 16,000 to 17,000 t of lithium contained in minerals and compounds in 2009, a decrease of approximately 25% from SQM's consumption estimate of 2008 (de Solminihac, 2010, p. 10). A different accounting of total world lithium consumption was reported by Roskill Information Services, which indicated consumption to be 18,600 t of lithium contained in minerals and compounds in 2009, a decrease of approximately 15% from Roskill's consumption estimate of 2008 (Baylis, 2010, p. 10, 13). The difference in consumption figures was most likely owing to differing estimations of consumer drawdown of existing lithium inventory. All industrial lithium demand sectors, including battery production, were negatively affected by the global economic downturn.

Total lithium consumption growth averaged 6% growth per year between 2004 and 2008, while lithium battery consumption growth averaged 21% per year during the same timeframe (de Solminihac, 2010, p. 10). Using Roskill's figure for total lithium consumption and the company's recent research that estimated the lithium chemical market to be about 75% of total lithium consumption, an estimated 14,000 t of lithium was consumed in chemicals and the remainder as mineral concentrates in the ceramics and glass industry in 2009 (Baylis, 2010, p. 5).

In 2008, China and Europe were estimated to be the largest consumers of lithium in the world, at 29% and 28% of total consumption, respectively. Other consumers included Japan, 18%; North America, 13%; Republic of Korea, 5%; India, 3%; South America, 2%; Russia, 1%; and other, 1% (Roskill Information Services Ltd., 2009, p. 155).

Argentina.—FMC has been operating its facility at the Salar de Hombre Muerto since 1998. It was initially designed to produce about 12,000 t/yr of lithium carbonate and about 5,500 t/yr of lithium chloride (North American Mineral News, 1998). In 2009, its lithium carbonate production capacity was 17,000 t/yr (Moores, 2009b). Lithium chloride production was more than 8,800 t in 2007. Production of lithium carbonate was estimated to be 7,000 t, a decrease of 30% from that of 2008. Production of lithium chloride was estimated to be 5,500 t, a decrease of 29% from that of 2008.

In 2009, Sentient's Rincon Lithium Ltd. continued ramping up pilot production at the Salar del Rincón in Salta Province and expected to achieve a lithium carbonate production rate of 1,500 t/yr in 2010. The lithium operation was designed to produce 10,000 t/yr of lithium carbonate, 4,000 t/yr of lithium hydroxide, and 3,000 t/yr of lithium chloride (Industrial Minerals, 2010a).

Australian exploration company Orocobre Ltd. announced in 2009 that its Olaroz lithium project at the Salar de Olaroz in northwestern Argentina contained 1.5 Mt inferred lithium carbonate resources. A scoping study was completed indicating the potential to develop a long-life operation with production of 15,000 t/yr of lithium carbonate. Orocobre also established a joint venture with Japanese trading house Toyota Tsusho Corp. Toyota Tsusho, a key supplier to Toyota Motor Corp. and several large Asian technology companies including Panasonic Corp. and Sanyo Electric Co., Ltd., anticipated using the joint venture as a means to secure low-cost lithium for its automotive and battery industry partners (Industrial Minerals, 2010b).

In 2009, Canadian exploration company Lithium Americas Corp. formed the Cauchari–Olaroz Salars project on the Puna plateau in northwestern Argentina. By yearend, a surface brine program, seismic geophysical program, nine reverse circulation drill holes, and five diamond drill holes were completed. The company entered into a strategic investment agreement with the Japanese firm Mitsubishi Corp., and completed a strategic investment agreement with Canadian car parts manufacturer Magna International Inc. The companies purchased 4.1% and 13.3%, respectively, of Lithium America's common shares in an effort to secure low-cost lithium supplies for their respective company's electric vehicle batteries (Hoffman and Keenan, 2010; Lithium Americas Corp., 2010, p. iv, 9–12).

Canadian-based resource company Lithium One Inc. formed the Sal de Vida lithium brine project at the Salar del Hombre Muerto. The company conducted systematic sampling of the near-surface brine during the fourth quarter of 2009. A drilling program was also initiated in December (Lithium One Inc., 2010, p. 2–3).

In December, Rodinia Minerals Inc. acquired a lithium deposit in the Salar de Salinas Grandes, in Jujuy Province. Previous studies on the brine chemistry in the salar found lithium concentrations in excess of 400 parts per million and a magnesium-to-lithium ratio of 3.75:1 (Metal-Pages, 2009).

Australia.—About 70% of the world's supply of lithium minerals was produced by Talison Lithium from its deposit in Western Australia, which reportedly is the largest spodumene deposit in the world (Department of Mines and Petroleum, 2009, p. 46). The company reported spodumene production of approximately 197,000 t in 2009 from its 260,000-t/yr plant, a decrease of 18% from that of 2008 (Department of Mines and Petroleum, 2010, p. 21; Talison Lithium Ltd., 2010). Lower grade spodumene was exported to China where it was converted into a range of lithium chemicals. Higher-grade spodumene was exported to Asia, Europe, and the United States where it was consumed by the ceramics, foundry, glass, and steel industries. In 2009, to meet future lithium demand, Talison continued improvements at the high-grade and low-grade sections of their lithium minerals plant with additional equipment and a new process to increase the lithia content in their spodumene concentrate (Geoscience Australia, 2009, p. 41).

In November, Galaxy Resources Ltd. officially broke ground at its Mount Cattlin spodumene operation, near Ravensthorpe in Western Australia. A definitive feasibility study for its Jiangsu lithium carbonate processing plant in Jiangsu Province of China was completed in October, and construction for the Jiangsu plant was scheduled to commence during the second quarter of 2010. Battery-grade lithium carbonate production capacity was set at 17,000 t/yr. An offtake agreement between Galaxy Resources and Mitsubishi was finalized and signed in February 2010, which gave Mitsubishi a significant portion of Galaxy's lithium carbonate production (Galaxy Resources Ltd., 2010, p. 4–11).

Bolivia.—Bolivia's undeveloped Salar de Uyuni is the largest salt flat in the world, with an area of more than 11,000 square kilometers. In August, Bolivia's state mining company Corporación Minera de Bolivia (Comibol) began a program to re-evaluate the Salar de Uyuni's lithium resources. Comibol planned to invest between $300 million and $400 million in a 30,000-t/yr lithium carbonate plant (Moores, 2009a). New World Resource Corp. announced it had acquired the Pastos Grandes brine property in southwestern Bolivia and initiated a brine sampling program. Further testing was planned for 2010 (New World Resource Corp., 2010).

Canada.—Tantalum Mining Corp. of Canada Ltd. (a subsidiary of Hudson Bay Mining and Smelting Co.), which had operated a spodumene mine and concentrating plant at Bernic Lake, Manitoba, on a commercial scale since 1986, suspended operations in September owing to the reduction in demand for spodumene concentrates in the ceramics and glass sector (Industrial Minerals, 2009e). Its most recent reported spodumene concentrate production capacity was 24,000 t/yr (Cabot Corp., 2002).

GlobeStar Mining Corp. estimated mineral resources of its pegmatite deposit near Moblan, Quebec, and predicted spodumene concentrate production of 22,000 t/yr. Exploration continued in 2009 (GlobeStar Mining Corp., undated).

Canada Lithium Corp. was evaluating the possibility of reopening the Quebec Lithium property–an underground mine, surface concentration plant, and chemical plant that operated from 1955 to 1965 and produced lithium carbonate, lithium chloride, lithium hydroxide monohydrate, and spodumene concentrate. Canada Lithium signed a marketing agreement with Mitsui and Co. Ltd. of Japan for exclusive rights to market the company's lithium in China, Japan, and the Republic of Korea. The company also completed a prefeasibility study indicating that the property had the potential to produce approximately 19,300 t/yr of battery-grade lithium carbonate (Canada Lithium Corp., 2010, p. 10).

Channel Resources Ltd. acquired the Fox Creek lithium brine project in Alberta from Polaris Capital Ltd. and initiated a brine sampling program. A previous study of the area by the Government of Alberta indicated potentially economic concentrations of lithium in the aquifer, comparable with those of the brine found in Clayton Valley, NV (Channel Resources Ltd., 2010, pg. 2–4). Lithium One completed two pegmatite drilling programs at its James Bay lithium project in Quebec (Lithium One, Inc., 2010, p. 11).

Chile.—With a reported 31% of the world lithium market, SQM reported a downturn in revenues from its lithium products as a result of the global economic slowdown in 2009. Sales volume, at 21,300 t, was 24% lower than in 2008, and the value of sales declined by 32% to $117.8 million. SQM's lithium carbonate production capacity was 42,000 t/yr, and its lithium hydroxide capacity was 6,000 t/yr in 2009; lithium capacity utilization rate was 57% (de Solminihac, 2010, p. 16; Sociedad Química y Minera de Chile S.A., 2010, p. 34, 55).

Total lithium carbonate production capacity for Chemetall Foote's operations in Chile and the United States increased to 31,000 t/yr in 2009. Production capacity was planned to increase to 33,000 t/yr by 2010; 40,000 t/yr by 2015; and 50,000 t/yr by 2020. Further increases to 65,000 t/yr would depend on market conditions. In addition, Chemetall planned to increase lithium hydroxide production capacity to 5,000 t/yr by 2010; 10,000 t/yr by 2015; and 15,000 t/yr by 2020 depending on market conditions. The company used lithium carbonate from Chile as feedstock for some of its downstream chemical production in Germany, Taiwan, and the United States. Chemetall reported a 50% share of the global market for its lithium products, with lithium carbonate accounting for 30% of the global market (Haber, 2009, p. 11; Industrial Minerals, 2009a; Haber, 2010, p. 14).

China.—China was the only country that continued to produce large quantities of lithium carbonate from both domestic and imported spodumene. Domestic lithium mineral concentrates were thought to be low grade and were most likely used in glass and ceramic applications. Higher grade spodumene concentrates imported from Australia were generally used in the production of battery-grade lithium carbonate. Ronghui (Jiangsu Province), Sichuan Tianqi Lithium Industries, Inc. (Sichuan Province), and Xinjiang Non-Ferrous Metals Industry Group, Ltd. (Xinjiang Province) were 80% to 100% reliant on Australian spodumene. Current lithium carbonate production capacity in China from minerals was estimated to be 41,000 t/yr; however, 2009 production was estimated to be about 15,500 t, well below capacity. Additional lithium carbonate was imported into China from Argentina and Chile. Lithium minerals were estimated to contain 35% of China's lithium reserves, while lithium brines were estimated to contain the remaining 65% of the reserves (Baylis, 2009, p. 6–7, 11, 13; Roskill Information Services Ltd., 2009, p. 89–91).

Chinese brine producers continued to have production problems in 2009, resulting in lithium output falling below expectations. The Tibet Lithium New Technology Development Co. had operated a 5,000-t/yr lithium carbonate plant at the Zabayu Salt Lake in western Tibet since 2005, with production capacity expected to eventually increase to 20,000 t/yr. CITIC Guoan Lithium Science & Technology Co., Ltd.'s 35,000-t/yr lithium carbonate plant (currently operating at a rate of 5,000 t/yr) was brought online in 2007 at the Taijinaier Salt Lake in Qinghai Province and was the largest lithium carbonate plant in China. In 2009, CITIC formed a joint venture with Chengdu Chemphys Chemical Industry Co., Ltd. of Sichuan, and signed a letter of intent with Japan's Toyota Tsusho to provide battery-grade lithium carbonate (Tahil, 2007, p. 10, 13; Baylis, 2010, p. 19). Qinghai Salt Lake Industry Group Co., Ltd. operated a 3,000-t/yr lithium carbonate plant at the Dongtai Salt Lake in Qinghai Province. Production capacity was expected to eventually increase to 20,000 t/yr. Total lithium carbonate production in 2009 from these three brine operations was estimated to be 4,100 t, well below their total capacity of 13,000 t/yr. Qinghai Salt Lake Lanke Lithium Industry Co., Ltd. completed construction of a 10,000-t/yr lithium carbonate project in the Chaerhan Salt Lake zone in Qinghai Province and produced 400 t of lithium carbonate in 2009 (Baylis, 2009, p. 11; Baylis, 2010, p. 19).

Finland.—In 2008, Norwegian mining company Nordic Mining ASA purchased a controlling stake in Finnish spodumene mining company Keliber Oy. The company then acquired a lithium deposit in the Lantta area of western Finland and planned to establish a 4,000-t/yr lithium carbonate plant, with production scheduled to begin in 2010. In 2009, Nordic investigated other lithium deposits surrounding the Lantta mine. When production begins, Nordic was expected to be the first European producer of lithium carbonate from domestic ore (Industrial Minerals, 2008; Nordic Mining ASA, 2010, p. 16).

Korea, Republic of.—As part of the Republic of Korea's effort to secure stable long-term supplies of lithium for its growing automobile, battery, and electronics industries, the Government partnered with key companies in the Republic of Korea, including POSCO and SK Energy, to acquire lithium from a broad range of sources and countries. In 2009, the Government of the Republic of Korea obtained technology to extract lithium from sea water. In early 2010, the Government signed an agreement with POSCO and the Korea Institute of Geoscience and Mineral Resources to conduct joint research and build a pilot plant for the commercial production of lithium from sea water. Construction was scheduled to be completed by 2014 (Moores, 2010a; Korea.net, 2010).

Serbia.—Jadarite, a new mineral species discovered in 2004 by Rio Tinto plc (London, United Kingdom) at Jadar was found to contain a high percentage of lithium oxide. In 2009, Rio Tinto announced plans to start lithium carbonate production in approximately 2015 and considered further development (Industrial Minerals, 2009c).

Outlook

The amount of lithium consumed globally for use in batteries increased by more than 20% per year during the past few years, although growth was less in 2009 owing to the global economic downturn. Demand for lithium-ion batteries appears to have the greatest potential for growth. Global sales of these rechargeable batteries were estimated to be $7.7 billion in 2009, with sales projected to increase by 13% per year to nearly $12 billion by 2013 (Credit Suisse Group AG, 2009). Other lithium end uses were increasing also but at lower rates than batteries. Roskill (2009, p. 156) indicated that annual growth in lithium consumed for pharmaceuticals had averaged 17% from 2000 to 2008, while lithium consumed for continuous casting and greases had 8-year growth rates of 8% and 6%, respectively. Roskill estimated that total world lithium consumption would increase to approximately 27,600 t in 2013, an increase of 48% from Roskill's consumption estimate for 2009 (Baylis, 2010, p. 13).

What was apparent in 2009 and will likely continue in the future was the tendency for Asian technology companies to invest in the development of lithium operations in other countries to ensure a stable supply of lithium for their battery industries. With lithium carbonate being one of the lowest cost components of a lithium-ion battery, the issue to be addressed was not cost difference or production efficiency but supply security attained by acquiring lithium from a number of different lithium sources (Moores, 2010b).

Research in nanotechnology, the understanding and control of matter at dimensions of approximately 1 to 100 nanometers, has advanced lithium-ion battery technology and further improvements are probable. By altering the nanostructures of the lithium-ion battery's anode and cathode, researchers have been able to increase battery storage capacity, output power, lifespan, and stability, while decreasing the time required to charge the battery (Harrop, 2008). Used in power tools, nanotechnology has enabled lithium-ion batteries to provide power surges of up to 10 times that of conventional lithium-ion batteries (Bullis, 2008). In hybrid vehicles, power surges from lithium-ion batteries enable a vehicle to accelerate faster than with other batteries of the same size (Pontin, 2007). A promising new technology, the lithium metal-air battery, may be capable of delivering 10 times more energy density than today's best lithium-ion technology, effectively offering the same energy density as gasoline. Development of lithium metal-air battery technology was expected to take between 5 and 10 years (Luoma, 2009).

Increased use of larger lithium-ion batteries can be attributed in part to use in heavy-duty power tools because lithium-ion batteries are continuously replacing nickel-cadmium batteries in power tools despite the current economic downturn and the somewhat higher prices that lithium-ion battery power tools generally command (Rockwood Holdings, Inc., 2009). According to a leading manufacturer of power tools, 70% of all cordless power tools in Europe were powered by lithium-ion batteries in 2009. The manufacturer expected lithium-ion power tools to account for 90% of the cordless power tool market by 2011 (Hartung, 2010).

Most global automobile manufacturers have announced plans to use lithium-ion batteries in current and future generations of HEVs, PHEVs, and EVs, in order of expected market entry. HEVs, PHEVs and EVs with lithium-ion batteries from companies such as BYD Co., Ltd. (China), Daimler AG (Germany), and Tesla Motors, Inc. (United States) saw limited release in 2009. Lithium-ion HEVs, PHEVs, and EVs are scheduled for release in 2010 by General Motors Company, Hyundai Group, Mitsubishi Motors Corp., Nissan Motor Company, Ltd., Toyota Motor Corp., and Volkswagen Group. Major automobile manufacturers have also formed partnerships with established battery manufacturers to build battery plants for hybrid vehicles and begin mass production of lithium-ion batteries. The worldwide market for lithium-ion batteries used in transportation was expected to increase to approximately $8 billion by 2015 from $876 million in 2010, largely fueled by government subsidies and incentives (Pike Research, 2009).

Pike Research indicated that utility-scale applications would be the downstream beneficiaries of the widespread research and innovation on lithium-ion battery development for the transportation sector. Of 11 competing energy storage technologies analyzed by Pike Research, lithium-ion batteries were forecast to be the fastest growing category for utility-scale applications, growing to a $1.1 billion worldwide business by 2018 (Reuters, 2009).

The use of lithium-ion batteries in HEVs, PHEVs, and EVs could greatly increase demand for lithium. As demand and prices rise, spodumene and other lithium resources that had been considered uneconomic might once again yield economically feasible raw materials for the production of lithium carbonate. New lithium mineral operations under development throughout the world in 2009 specifically to produce battery-grade lithium carbonate demonstrated a renewed interest in lithium exploration and development.

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Roskill Information Services Ltd.

TABLE 1

SALIENT LITHIUM STATISTICS[1]

(Metric tons of contained lithium)

	2005	2006	2007	2008	2009
United States:					
Production	W	W	W	W	W
Exports[2]	1,720	1,500	1,440	1,450	919
Imports[2]	3,580	3,260	3,140	3,160	1,890
Consumption[e]	2,500	2,500	2,400	2,300	1,300
Rest of world, production[3]	21,500 [r]	24,300 [r]	25,400 [r]	25,800 [r]	18,800 [e]

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Compounds. Source: U.S. Census Bureau.

[3] Mineral concentrate and lithium carbonate.

TABLE 2

U.S. EXPORTS OF LITHIUM CHEMICALS, BY COMPOUND AND COUNTRY[1]

	2008		2009	
Compound and country	Gross weight (metric tons)	Value[2] (thousands)	Gross weight (metric tons)	Value[2] (thousands)
Lithium carbonate:				
Australia	52	$373	11	$88
Canada	164	611	157	662
Germany	561	3,490	576	3,970
India	37	157	37	238
Japan	1,290	7,710	--	--
Korea, Republic of	100	678	80	514
Kuwait	--	--	42	831
Malaysia	117	693	--	--
Mexico	--	--	20	175
United Kingdom	313	1,160	53	241
Other	26	109	19	83
Total	2,660	15,000	995	6,800
Lithium carbonate, U.S.P.:[3]				
Australia	--	--	13	75
India	12	130	6	166
Mexico	20	4	--	--
United Kingdom	15	137	(4)	9
Other	10	533	11	76
Total	57	804	30	326
Lithium hydroxide:				
Argentina	146	1,600	65	556
Australia	41	313	64	478
Canada	107	446	90	438
China	123	867	37	345
Colombia	74	510	63	521
Egypt	58	394	73	493
Germany	996	5,860	397	2,490
India	267	1,500	81	436
Japan	2,210	16,400	1,870	14,200
Korea, Republic of	268	2,100	249	1,750
Mexico	70	584	68	322
Netherlands	230	1,250	99	535
Peru	17	126	6	40
Russia	315	1,680	63	348
Saudi Arabia	55	388	89	742
Singapore	53	344	21	318
South Africa	79	824	77	690
Taiwan	85	588	56	357
Thailand	240	1,590	155	933
United Kingdom	102	1,620	673	4,380
Venezuela	56	496	78	704
Vietnam	30	229	24	180
Other	58	959	10	347
Total	5,680	40,700	4,400	31,600

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship values.

[3] Pharmaceutical-grade lithium carbonate.

[4] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF LITHIUM CHEMICALS BY COMPOUND AND COUNTRY[1]

Compound and country	2008		2009	
	Gross weight (metric tons)	Value[2] (thousands)	Gross weight (metric tons)	Value[2] (thousands)
Lithium carbonate:				
Argentina	7,300	$33,600	6,220	$29,700
Chile	8,110	34,400	2,900	11,400
China	14	75	107	454
Other	7 r	122 r	26	269
Total	15,400	68,200	9,250	41,900
Lithium carbonate, U.S.P., Chile[3]	341	1,890	--	--
Lithium hydroxide:				
Chile	816	5,410	510	3,070
China	279	1,480	306	1,440
Germany	2	27	13	526
India	20	187	28	188
Japan	7	131	15	81
Norway	24	54	21	54
Romania	3	17	--	--
United Kingdom	11	58	37	201
Other	2 r	39 r	2	30
Total	1,160	7,400	932	5,580

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

[3] Pharmaceutical-grade lithium carbonate.

Source: U.S. Census Bureau.

TABLE 4
LITHIUM MINERALS AND BRINE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009e
Argentina:[4]					
Lithium carbonate	7,288	8,228	8,863	9,984 r	7,000
Lithium chloride	8,416	8,336	8,828 r	7,800	5,500
Australia, spodumene	173,635	222,101	192,277	239,528 r	200,000
Brazil, concentrates	8,924	8,585	7,991	8,000 e	8,000 p
Canada, spodumene[e, 5]	22,500	22,500	22,500	22,000	10,000
Chile:[4]					
Lithim carbonate from subsurface brine	43,091 r	46,241 r	51,292 r	48,469 r	25,154 [6]
Lithium chloride	681	1,166	4,185	4,362 r	2,397 [6]
Lithium hydroxide	504	3,794	4,160	4,050	2,987 [6]
China, carbonate[e]	15,000	15,000	16,000	17,500	20,000
Portugal, lepidolite	26,185	28,497	34,755	-- r	--
United States, subsurface brine	W	W	W	W	W
Zimbabwe, amblygonite, eucryptite, lepidolite, petalite, and spodumene[e]	37,499 [6]	30,000	30,000	25,000	20,000

e Estimated. p Preliminary. r Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Table includes data available through March 20, 2010.

[2] Estimated data are rounded to no more than three significant digits.

[3] In addition to the countries listed, other nations may produce small quantities of lithium minerals, but output is not reported, and no valid basis is available for estimating production levels.

[4] New information was available from Argentine and Chilean sources, prompting major revisions in how lithium production was reported.

[5] Based on all Canada's spodumene concentrates (Tantalum Mining Corp. of Canada Ltd.'s Tanco property).

[6] Reported figure.

MAGNESIUM

By Deborah A. Kramer

Domestic survey data and tables were prepared by Paula R. Neely, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

Primary magnesium was produced by one company in the United States, and much of the U.S. demand was met by imports. Israel was the principal source of imported magnesium metal and alloys. Aluminum alloying, diecasting, and iron and steel desulfurization, in descending order, were the principal end-use applications for magnesium in the United States in 2009. Consumption of magnesium in the United States in 2009 was significantly lower than that of 2008 mainly because of the global economic decline. Decreases in primary aluminum production and secondary aluminum recovery contributed to the overall decline in domestic consumption of magnesium. China continued to dominate world production of primary magnesium, accounting for 82% of the total (excluding the United States).

Legislation and Government Programs

The U.S. Department of Commerce, International Trade Administration (ITA) (2009a), published the final results of its administrative review of antidumping duties on pure magnesium imported from Russia. Solikamsk Magnesium Works did not ship magnesium to the United States during the period of review (April 1, 2007, through March 31, 2008), so the ITA rescinded the antidumping duty order for Solikamsk. The other Russian magnesium producer, VSMPO-Avisma Corp. (Avisma), chose not to participate in the administrative review, and requested that the ITA remove all proprietary information on Avisma from the record. As a result of the decision not to participate, the ITA used what it termed "adverse facts available" to determine Avisma's dumping margin, which was 43.58% ad valorem for pure magnesium. Antidumping duty rates for other Russian firms were set at 21.01% ad valorem.

In December, the ITA published its final antidumping duty administrative review for pure magnesium imported from the Chinese firm Tianjin Magnesium International Co. Ltd. (TMI). According to the ITA, TMI withheld information and provided information that could not be verified during the investigation. TMI's suppliers reportedly lacked documentation of payment, had recordkeeping discrepancies, and had altered requested documents. As a result, the ITA set a punitive antidumping duty of 111.73% ad valorem (Jenneman, 2009d; U.S. Department of Commerce, International Trade Administration, 2009b). TMI planned to appeal the decision before the U.S. Court of International Trade.

The United States was seeking the formation of a formal World Trade Organization (WTO) panel on a complaint filed on June 23 alleging that China improperly restricted exports of materials to help its own manufacturers. The United States and the 27-nation European Union filed the initial complaint at the WTO on June 23, and Mexico joined the complaint on August 21. According to the complaint, China imposed quotas on exports of some materials and imposed export duties on several raw materials. The materials included in the complaint were bauxite, coke, fluorspar, magnesium, manganese, silicon metal, silicon carbide, yellow phosphorus, and zinc (Agence France-Presse, 2009). In December, the WTO Dispute Settlement Body set up a panel in response to this complaint. The panel was scheduled to complete its report of findings and recommendations within 9 months after it was established (Office of the United States Trade Representative, 2009). Several other nations, including Canada, planned to participate in the panel.

Production

U.S. Magnesium LLC was the sole producer of primary magnesium in the United States. The company recovered magnesium electrolytically from brines from the Great Salt Lake at its 52,000-metric-ton-per-year (t/yr) plant in Rowley, UT. U.S. Magnesium announced that it would reduce production and delay expansion at its plant, citing weak demand as the reason for the announced actions. U.S. Magnesium had planned on increasing production capacity to 70,000 t/yr by 2010, but this would be delayed until demand improves (McBeth and de Klerk, 2009).

Environmental Issues

The cover gas sulfur hexafluoride (SF_6) that is used to protect molten magnesium from oxidation has been identified as a potential factor in global warming. Although studies on the gas's effect continued, its long atmospheric life (about 3,000 years) and high potential as a greenhouse gas (23,900 times the global warming potential of carbon dioxide) resulted in a call for voluntary reductions in emissions. In 1999, the U.S. magnesium industry, the International Magnesium Association, and the U.S. Environmental Protection Agency (EPA) began a voluntary partnership to reduce emissions of SF_6. The major processes that require SF_6 melt protection are primary production; secondary production; die, permanent mold, and sand casting; wrought products production; and anode production. According to the EPA, the magnesium industry emitted 2.0 teragrams CO_2 equivalent of SF_6 in 2008, representing a decrease of approximately 23% from 2007 emissions. The decrease may be attributed to die casting facilities closing in the United States during 2008 because of reduced demand from the American automobile industry and other industrial sectors. An issue that was expected to be addressed in future inventories is the likely adoption of alternate cover gases by U.S. magnesium producers and processors. These cover gases, which include AM-cover™ (containing hydroflurocarbon-134a) and Novec™ 612 (dodecafluoro-2-methylpentan-3-one), have lower global warming potential than SF_6 and tend to quickly decompose during their exposure to the molten metal. Magnesium producers and processors voluntarily have begun using these cover gases in a limited fashion (U.S. Environmental Protection Agency, 2010).

After an investigation begun in late 2008, the EPA added U.S. Magnesium's Tooele County, UT, operations to the national priorities list of Superfund sites. Superfund is the name of the fund established by the Comprehensive Environmental Response, Compensation and Liability Act of 1980. Designation as a Superfund site allows the EPA to clean up such sites and to compel responsible parties to perform cleanups or reimburse the Government for EPA-led cleanups. The designated site encompasses 1,830 hectares (4,530 acres) on the southwestern edge of the Great Salt Lake, 64 kilometers (40 miles) from Salt Lake City, UT. Contaminants at the site include acidic wastewater, dioxins, furans, heavy metals, hexachlorobenzene, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons. U.S. Magnesium planned to challenge the designation (Jennemann, 2009c; U.S. Environmental Protection Agency, 2009).

In a separate but related lawsuit, U.S. Magnesium and the EPA were in the U.S. Court of Appeals on November 18 as a result of a suit brought by the EPA in 2001 that alleged U.S. Magnesium violated the Resource Conservation and Recovery Act. The EPA alleged that dioxins and other cancer-causing agents that are byproducts of the magnesium extraction process are a threat to workers, wildlife, and public health. U.S. Magnesium claimed that Congress excluded the company from the law and that the EPA was retroactively applying new guidelines. In a 2007 ruling, a U.S. District Court judge ruled in favor of U.S. Magnesium, and the EPA appealed the decision (Coffman, 2009).

Consumption

Data for magnesium metal are collected from two voluntary surveys of U.S. operations by the U.S. Geological Survey. Of the 64 companies canvassed for magnesium consumption data, 53% responded, representing 59% of the magnesium-base scrap consumption listed in table 2 and the primary magnesium consumption listed in table 3. Data for the 30 nonrespondents were estimated on the basis of prior-year consumption levels and other factors.

Reported primary magnesium consumption in 2009 was about 21% lower than that in 2008 (table 3), reflecting the effects of the global economic downturn. Aluminum alloying was the principal use for primary magnesium, accounting for 45% of the total, followed by diecasting with 37% and iron and steel desulfurization with 8%. Primary magnesium use in aluminum alloying decreased by 34%, which mirrored the decline in U.S. primary aluminum production. The 36% decline in U.S. steel production from 2008 to 2009 resulted in a significant drop in the use of magnesium in iron and steel desulfurization of 44%.

In contrast, primary magnesium consumption for diecasting applications was 18% higher than that in 2008, but still at a level significantly lower than before the economic crisis that began in 2008. This increase may have been partially attributed to the Car Allowance Rebate System (CARS), more commonly known as "Cash for Clunkers," which was a Federal Government $3 billion automobile scrapping program intended to provide economic incentives to U.S. residents to purchase new, more fuel-efficient vehicles when trading in less fuel-efficient vehicles. The program officially started on July 1, 2009, the processing of claims did not begin until July 24, and the program ended on August 24, as the appropriated resources were exhausted with sales of about 700,000 new vehicles (U.S. Department of Transportation, 2009). Despite increased sales of automobiles during July and August, the International Organization of Motor Vehicle Manufacturers (2010) reported that U.S. vehicle production in 2009 decreased by 34.3% from that in 2008, and production in Canada also was 28.5% lower.

Magnesium recovery from scrap also was 20% lower than that in 2008 mainly as a result of smaller quantities of aluminum scrap being processed.

In December, Allegheny Technologies Inc. (ATI) began initial production at its titanium sponge facility in Rowley. The company planned to systematically increase production during 2010 until the plant reaches its full capacity. When this Utah sponge facility is fully operational, ATI's total sponge production capacity (including the Albany, OR, facility) was projected to be about 20,900 t/yr. The company also temporarily idled its Albany sponge production facility in July because of a decline in the commercial aerospace market (Allegheny Technologies Inc., 2010, p. 19, 22). Magnesium consumption would be expected to increase with increased titanium production because magnesium is used in the Kroll process to reduce titanium tetrachloride to titanium sponge.

On January 30, Contech, LLC (Portage, MI) filed a petition under chapter 11 of the U.S. Bankruptcy Code to restructure its business, citing unprecedented low volumes of diecastings used by the automobile industry as the reason. The company produced aluminum and magnesium diecastings for the automobile industry and has plants in Michigan, Indiana, Tennessee, and the United Kingdom, but only the U.S. operations were affected by the chapter 11 filing (Contech, LLC, 2009). In June, the U.S. Bankruptcy Court in Michigan approved the sale of Contech's aluminum and magnesium diecasting assets to Revstone Industries LLC.

In addition, one of the leading aluminum sheet producers, Aleris International Inc. filed for chapter 11 bankruptcy protection in mid-February citing a decrease in demand from the automobile industry as the principal reason for the filing. Only the company's U.S. operations were affected by the filing. Aleris was a leading consumer of magnesium at its rolling and recycling operations, and companies such as U.S. Magnesium, Dead Sea Magnesium Ltd., and Advanced Magnesium Alloys Corp. were among the company's creditors (McBeth, 2009a).

Aluminum and magnesium diecaster Spartan Light Metal Products Inc. announced that it would cut production and lay off employees in response to a 30% decrease in diecasting orders for the first quarter of 2009. Other magnesium diecasters reported that they would extend plant shutdowns into January, and many had enough magnesium alloy inventory to supply plant requirements for 8 weeks to 6 months (McBeth, 2009c).

Aluminum and magnesium diecaster Intermet Corp. began selling its assets as a result of its chapter 11 bankruptcy filing in August 2008. The company had closed some of its plants in 2008, including its Pulaski, TN, plant, where it manufactured aluminum and magnesium automotive diecastings. Continental Casting LLC

(Perry, MO) purchased two plants from Intermet—one in Monroe City, MO, that produced aluminum and zinc castings and one in Palmyra, MO, that produced aluminum and magnesium castings. Continental Casting planned to continue to operate the facilities and retain the plant employees (McBeth and Gilcrest, 2009).

Quad City Die Casting Co. closed its Moline, IL, diecasting facility in September because of the slowdown in demand from its principal customer, American Kawasaki Motorcycle Corp. Quad City produced aluminum, magnesium, and zinc diecastings. Approximately 100 workers were laid off (Murphy, 2009).

Stocks

Producers' yearend 2009 stocks of primary magnesium were about the same as those at yearend 2008; producer stock data were withheld to avoid disclosing company proprietary data. Consumer stocks of primary and alloy magnesium were 4,850 metric tons (t) at yearend 2009, 38% lower than the yearend 2008 level of 7,810 t (revised).

Prices

In 2009, prices continued the decline begun in the fourth quarter of 2008. Most of the decline in prices in the United States early in the year resulted from renegotiations of contracts, not spot sales. In addition, consumers were delaying deliveries because of the slowdown in the magnesium end-use markets and in consumption in secondary aluminum products (Jennemann, 2009a). By midyear, consumers had significant quantities of magnesium left in their 2009 contracts and were not negotiating contracts for 2010 yet, and spot magnesium sales were almost nonexistent (Jennemann, 2009b). By yearend, prices were significantly lower than those at yearend 2008 in response to the weak global economy and weak magnesium demand.

In November, contract negotiations for 2010 began in Europe and the United States as large aluminum companies solicited offers. Several significant aluminum buyers in Europe settled first quarter 2010 contracts for Chinese-origin magnesium at $2,600 to $2,650 per metric ton. U.S. contracts with the leading aluminum producers, however, were not completed by yearend, although offers at $2.20 per pound were reported (McBeth, 2009b).

Foreign Trade

Total magnesium exports for 2009 were about 36% higher than those in 2008 (table 5). Canada (52%), Singapore (14%), and Mexico (13%) were the principal destinations.

Magnesium imports for consumption in 2009 were about 43% less than those in 2008 (table 6). Magnesium metal (containing at least 99.8% by weight of magnesium) imports were 52% lower compared with those in 2008, and alloy imports were 63% lower. Reduced consumption by the automotive diecasting industry after the closure of several U.S. diecasting plants was the main reason for the decline in alloy imports. Israel (71%) was the principal source of imported magnesium metal and of imported alloys (22%).

World Review

Canada.—Timminco Ltd. completed the divestiture of its magnesium business in July. The company merged its remaining extrusion businesses with the magnesium operations of China-based Winca Tech Ltd. to form Applied Magnesium International Ltd. Timminco's facility in Nuevo Laredo, Mexico, and Winca's facilities in Hebi, Henan Province, and Linyi, Shandong Province, China, were included in the new company. Former managers and employees of Timminco's magnesium business were expected to form the core management team of its North American operations, based in Denver, CO, where Timminco's magnesium extrusion facility was located. In connection with the sale, Timminco received a 19.5% equity interest in Applied Magnesium; Winca held the remaining equity (Timminco Ltd., 2009).

In November, Swiss firm Xstrata plc began demolishing the 63,000-t/yr Magnola magnesium plant in Asbestos, Quebec. The plant had been constructed in 2000 by the former Noranda Inc. to recover magnesium from asbestos tailings but was closed in 2003 because magnesium produced at Magnola could not compete with lower priced magnesium from China in the world market. Norsk Hydro ASA's 48,000-t/yr magnesium plant in Becancour, Quebec, had been demolished earlier in 2009 (McDougall, 2009).

Trimag L.P. announced that it was closing its Boisbriand, Quebec, diecasting plant in June following the loss of its major customer, General Motors Corp. (GM), to which Trimag had supplied nearly all of its high-pressure diecastings. GM canceled its business with Trimag because of low automotive demand. The plant had been idle since late 2008, and 160 workers were permanently laid off. Trimag also had shut down an Ontario magnesium diecasting plant in 2007 (CNW Group, 2009).

China.—According to the China Nonferrous Metals Industry Association, China produced 500,000 t of magnesium in 2009, 5% lower than production in 2008 (China Magnesium Industry & Market Bulletin, 2010).

In January, Taiyuan Tongxiang Magnesium Co. Ltd. (Shanxi Province) reportedly cut its production to 3,000 metric tons per month (t/mo) from the 10,000-t/mo rate at which it had been producing in 2008. Only 5 of the company's 25 magnesium plants were in operation. Persistent weakness in demand in China's automotive sector and a forecast for this weakness to continue were the principal reasons for the shutdown. Taiyuan Tongxiang's total magnesium production capacity was 100,000 t/yr (Metal-Pages, 2009a). Other magnesium producers in China also reported that they would cut production and delay expansions until the market improves.

Although magnesium production has declined in China, companies still were announcing capacity increases. Ningxia Huaying Mining Group Co. (Ningxia Autonomous Region) commissioned the first phase of its magnesium alloy facility at the end of October. The first phase of the facility was designed to produce 50,000 t/yr of magnesium alloys. Total investment in the project, which would have an alloy production capacity of 150,000 t/yr when completed in 2012, was expected to be $587 million (Metal-Pages, 2009c). Qinghai Salt Lake Industry Group Co. Ltd. (Qinghai Province) reportedly was buying equipment from North America to construct a 50,000-t/yr magnesium metal plant. The equipment was scheduled to be delivered by October, and construction was expected to be completed by 2011. Qinghai also planned to expand capacity to 100,000 t/yr in the future.

The proposed plant would recover magnesium from magnesium chloride extracted from salt lakes in the Qinghai-Tibet plateau from which the company produced salt (Metal-Pages, 2009b). Fugu Coal & Chemical Group Co. Ltd. (Shaanxi Province) planned to complete a magnesium production facility with a total production capacity of 180,000 t/yr by yearend. Production capacity at the facility was 40,000 to 50,000 t/yr (Platts Metals Week, 2009a).

Ningxia Huiye Magnesium Co. Ltd. (Ningxia Autonomous Region) completed its magnesium ingot expansion project in June, increasing production capacity to 66,000 t/yr from 40,000 t/yr. The company, which has five plants in Ningxia Hui Autonomous Region and Shanxi Province, had originally planned to finish the expansion project before yearend 2008, but delayed the expansion because of rapidly falling magnesium prices and the global economic crisis (Metal-Pages, 2009d).

China Direct Industries, Inc. (Deerfield Beach, FL) signed a letter of intent with Taiyuan Yiwei Magnesium Group Ltd. (Shanxi Province) to acquire the minority interest in Taiyuan Changxin Magnesium Co. Ltd. (Shanxi Province), Shanxi Gu County Golden Magnesium Co. Ltd. (Shanxi Province), and Baotou Xinjin Magnesium Industry Co. Ltd. (Inner Mongolia Autonomous Region) (subsidiaries of Yiwei Magesium). In addition, China Direct was seeking to acquire up to five additional magnesium facilities from Yiwei Magnesium. These five facilities have a combined production capacity of 40,000 t/yr of pure magnesium ingot, 10,000 t/yr of magnesium powder, and 10,000 t/yr of magnesium alloy. China Direct also planned to sell its interest in Pan Asia Magnesium Co. Ltd. (China Direct Industries, Inc., 2009).

The municipal government of Anshan, Liaoning Province, secured investment through Magnesium Resources Corp. of China Ltd. to build a magnesium plant in the city's Haicheng district. Magnesium Resources was expected to invest up to $1.5 billion in the construction of the facility, which would have a capacity of 200,000 t/yr of magnesium metal and 50,000 t/yr of magnesium alloys. The first phase of the project was expected to be completed in mid-2010 (Metal-Pages, 2010a).

Israel.—In July, Israel Chemicals Ltd. (ICL) and Volkswagen AG reached a compromise regarding Volkswagen's demand to pull out of its partnership in Dead Sea Magnesium Ltd. Under the accord, Volkswagen would provide $30 million to Dead Sea Magnesium's 35,000-t/yr primary magnesium plant and transfer its 35% share in the company to ICL, which owns the other 65%. At the same time, ICL would provide $55.7 million in funds to Dead Sea Magnesium (Reuters, 2009). The companies had been negotiating Volkswagen's withdrawal from the venture since December 2008.

Malaysia.—CVM Minerals Ltd. announced that it was delaying completion of its primary magnesium plant under construction in Perak, which was originally scheduled to be completed in March. CVM has the rights to mine dolomite from the nearby Dolomite Hills and was constructing the first of two production lines for magnesium with a 15,000-t/yr capacity. When the second line is completed, the plant's total capacity was projected to be 30,000 t/yr. At yearend, construction of the Perak magnesium plant was in progress. The reduction furnaces were being tested, and some modifications were required. The company estimated that the tests would be completed in March 2010, and commercial production was scheduled for April (Platts Metals Week, 2009b; CVM Minerals Ltd., 2010, p. 1).

Norway.—SilMag D.A. (a 50-50 joint venture between Norsk Hydro ASA and AMG Advanced Metallurgical Group N.V. of the Netherlands) planned to postpone secondary magnesium alloy production, which was originally scheduled to start in 2009, in Porsgrunn. The company cited the decline in magnesium consumption and price since autumn 2008 and difficulty in magnesium scrap collection (Metals Place, 2009a). In October, SilMag began testing at a pilot plant to recover magnesium chloride from olivine. Testing was expected to continue through May 2010, but the company would not commercialize the process until a user is found for the silica that is generated in the process (Metals Place, 2009b). The joint-venture project planned to recover magnesium at Norsk Hydro's former primary magnesium plant that closed in 2002.

Russia.—Magnesium shipments at Solikamsk in 2009 totaled 12,120 t of metal and alloy, nearly 27% less than those in 2008. Solikamsk cited the global economic downturn and a significant stockpile of product at producers' and customers' warehouses as factors contributing to the decrease in shipments. Because of the slump in demand, the company shut down 65% of its electrolytic magnesium production capacity and reduced the workweek of its employees (Metal-Pages, 2010c).

Outlook

U.S. magnesium consumption was expected to continue to be directly correlated to the global economy. If the economy recovers, magnesium consumption in the United States should return to its earlier levels. A significant portion of U.S. demand for magnesium will depend on its use in aluminum alloys. Aluminum production in the United States was not projected to increase significantly until producers were certain of a sustained economic recovery; in mid-2010, only about 50% of the U.S. primary aluminum production capacity was in use.

Most of the growth in magnesium use in the past decade resulted from its increased use in automotive applications, and any increase in automobile manufacturing would be expected to result in an increase in the use of magnesium because of its light weight. However, automotive manufacturers may be less likely to choose magnesium than other lightweight materials, such as plastic, because of the limited availability from multiple producers. Because of antidumping duties assessed on magnesium imported from China and Russia, automobile manufacturers are limited to sourcing primary magnesium from one company in Brazil, one in Israel, and one in the United States; the limited number of suppliers was one of the reasons that the U.S. automotive industry was reluctant to use magnesium for many years. In May 2010, the North American Die Casting Association (NADCA) submitted comments to the ITC in a 5-year review of duties for magnesium that indicated that the lack of effective competition in the U.S. market has harmed die casters since the imposition of the antidumping duty orders in 2005. The NADCA estimated that as many as 1,675 direct jobs and 8,000 supporting jobs have been lost in the diecasting industry as a result of the imposition of these orders (North American Die Casting Association, 2010). Ultimately, the sustained use of magnesium in automotive applications may depend on its availability from multiple sources.

Analysts at Clark & Marron Pty. Ltd. projected that, after decreasing by 20% to 480,000 t in 2009 from that in 2008, global magnesium demand was expected to grow by an average of 7.9% per year through 2019. The growth in demand was expected to be driven by the increased use of magnesium in diecasting and aluminum alloys (Metal-Pages, 2010b).

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Platts Metals Week.

TABLE 1

SALIENT MAGNESIUM STATISTICS[1]

(Metric tons unless otherwise specified)

		2005	2006	2007	2008	2009
United States:						
Production:						
Primary magnesium		W	W	W	W	W
Secondary magnesium		73,300	81,900 r	84,100 r	83,700 r	66,600
Exports		9,650	12,300	14,800	14,400	19,600
Imports for consumption		84,700	75,300	71,800	83,300	47,300
Consumption, primary		82,100	77,600	72,200	64,500 r	50,900
Yearend stocks, producer		W	W	W	W	W
Price[2]	dollars per pound	1.15–1.30	1.35–1.45	2.00–2.50	3.05–3.25	2.20–2.40
World, primary production[e]		622,000	675,000	751,000	670,000 r	608,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.

[1]Data are rounded to no more than three significant digits.

[2]Source: Platts Metals Week.

TABLE 2

MAGNESIUM RECOVERED FROM SCRAP PROCESSED IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY[1]

(Metric tons)

	2008	2009
KIND OF SCRAP		
New scrap:		
Magnesium-base	22,400 r	17,200
Aluminum-base	38,700 r	29,900
Total	61,100 r	47,100
Old scrap:		
Magnesium-base	1,210	1,210
Aluminum-base	21,300 r	18,300
Total	22,600 r	19,500
Grand total	83,700 r	66,600
FORM OF RECOVERY		
Magnesium alloy ingot[2]	W	W
Magnesium alloy castings	7,880 r	7,970
Magnesium alloy shapes	-- r	--
Aluminum alloys	62,000 r	49,700
Other[3]	13,800 r	8,900
Total	83,700 r	66,600

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Other." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes secondary magnesium content of both secondary and primary alloy ingot.

[3] Includes chemical and other dissipative uses, cathodic protection, and data indicated by symbol W.

TABLE 3

U.S. CONSUMPTION OF PRIMARY MAGNESIUM, BY USE[1]

(Metric tons)

Use	2008	2009
For structural products:		
Castings:		
Die	16,200 r	19,100
Permanent mold	19	44
Sand	428	410
Wrought products[2]	2,480	1,160
Total	19,100 r	20,700
For distributive or sacrificial purposes:		
Aluminum alloys	35,000	23,000
Cathodic protection (anodes)	824	686
Iron and steel desulfurization	7,070	3,970
Nodular iron	61	72
Reducing agent for titanium, zirconium, hafnium, uranium, beryllium	1,320	1,120
Other[3]	1,080	1,350
Total	45,300	30,200
Grand total	64,500 r	50,900

rRevised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes sheet and plate and forgings.

[3] Includes chemicals and scavenger, deoxidizer, and powder.

TABLE 4
YEAREND MAGNESIUM PRICES

Source		2008	2009
Platts Metals Week:			
U.S. spot dealer import	dollars per pound	3.00–3.25	2.25–2.40
U.S. spot Western	do.	3.05–3.25	2.20–2.40
China	dollars per metric ton	2,900–3,000	2,630–2,700
European free market	do.	2,900–3,000	2,700–2,800
Metal Bulletin:			
China free market	do.	2,800	2,700–2,780
European free market	do.	2,800–2,900	2,700–2,750

do. Ditto.

TABLE 5
U.S. EXPORTS OF MAGNESIUM, BY COUNTRY[1]

Country	Waste and scrap		Metal		Alloys		Powder, sheets, tubing, ribbons, wire, other forms	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2008:								
Brazil	--	--	--	--	699	$3,750	14	$517
Canada	1,290	$3,240	666	$2,300	4,540	18,500	287	4,000
Mexico	1,070	1,660	565	1,470	524	3,470	688	3,780
Singapore	--	--	1,770	5,780	10	32	13	286
United Kingdom	58	151	12	24	14	52	432	11,300
Other	176	366	89	188	976	4,130	517	10,400
Total	2,600	5,420	3,100	9,770	6,760	29,900	1,950	30,200
2009:								
Brazil	--	--	220	648	2,090	10,100	21	761
Canada	2,050	4,630	2,610	8,470	5,290	22,100	217	3,330
Mexico	165	453	520	1,800	1,050	4,760	881	5,480
Singapore	--	--	2,550	9,150	262	944	9	191
United Kingdom	--	--	--	--	10	51	340	10,300
Other	67	119	221	461	488	2,470	581	10,500
Total	2,280	5,200	6,120	20,500	9,190	40,400	2,050	30,500

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF MAGNESIUM, BY COUNTRY[1]

	Waste and scrap		Metal		Alloys, magnesium content		Powder, sheets, tubing, ribbons, wire, other forms, magnesium content	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2008:								
Canada	15,400	$28,500	6	$21	3,040	$17,100	1,350	$7,500
China	106	295	19,100	95,000	196	1,570	511	4,140
Israel	--	--	21,800	81,100	3,940	17,400	--	--
Kazakhstan	--	--	256	678	--	--	--	--
Mexico	1,520	1,930	--	--	1,060	4,770	(2)	2
Russia	--	--	2,210	7,530	--	--	15	355
Other	7,090	28,000	878	5,560	4,730	33,200	96	2,690
Total	24,100	58,800	44,300	190,000	13,000	74,100	1,970	14,700
2009:								
Canada	14,800	24,300	22	112	687	3,360	2	85
China	50	49	4,970	22,600	133	649	122	1,530
Israel	--	--	15,300	58,500	1,040	4,890	--	--
Kazakhstan	--	--	333	918	--	--	--	--
Mexico	805	1,290	25	210	683	2,660	6	323
Russia	--	--	307	1,200	8	75	2	102
Other	5,250	14,700	438	3,190	2,240	18,200	73	2,130
Total	20,900	40,300	21,400	86,800	4,790	29,800	205	4,170

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7
WORLD ANNUAL PRIMARY MAGNESIUM PRODUCTION CAPACITY, DECEMBER 31, 2009[1]

(Metric tons)

Country	Capacity
Brazil	18,000
China	1,030,000
India	900
Israel	27,500
Kazakhstan	10,000
Russia	80,000
Serbia and Montenegro	5,000
Ukraine	15,000 [2]
United States	52,000
Total	1,240,000

[1] Includes capacity at operating plants as well as at plants on standby basis.

[2] Idle.

TABLE 8
MAGNESIUM: ESTIMATED PRIMARY WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2005	2006	2007	2008	2009
Brazil	6,000	6,000	18,000	15,000	16,000
Canada[3]	50,000	65,000	16,300	2,000 [r]	--
China	470,000	520,000	625,000	559,000	501,000
Israel[4]	27,853	24,581	29,618	32,051 [r]	29,000
Kazakhstan	20,000	21,000	21,000	21,000	21,000
Russia[3]	45,000	35,000	37,000	37,000	37,000
Serbia	1,500 [5]	1,500	2,000 [r]	1,500	1,500
Ukraine	2,000	2,200	2,500	2,000 [r]	2,000
United States	W	W	W	W	W
Total	622,000	675,000	751,000	670,000 [r]	608,000

[r] Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 13, 2010.

[3] Includes secondary.

[4] Reported figure.

[5] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

MAGNESIUM COMPOUNDS

By Deborah A. Kramer

Domestic survey data and tables were prepared by Paula R. Neely, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

U.S. production of caustic-calcined magnesia and dead-burned (refractory) magnesia decreased from the levels in 2008. Imports continued to account for more than one-half of U.S. consumption of magnesia. Consumption of refractory magnesia was less than one-half the level in 2008, reflecting the decline in steel production. Caustic-calcined (and other) magnesia consumption decreased by about 19%, with imports of caustic-calcined (and other) magnesia accounting for about 45% of total U.S. consumption.

About 53% of U.S. magnesium compounds production came from seawater and well and lake brines. The remainder was recovered from dolomite, magnesite, and olivine. About 60% of the total consumption of magnesium compounds was used in agricultural, chemical, environmental, and other applications. The remaining 40% was for refractory applications. China remained the dominant supplier of imports for caustic-calcined and refractory (dead-burned and fused) magnesias, with 63% and 64%, respectively, of the totals.

Legislation and Government Programs

In August, the U.S. Department of Commerce, International Trade Administration (ITA), began an antidumping duty investigation of imports of magnesia-carbon bricks from China and Mexico and a countervailing duty investigation of imports of magnesia-carbon bricks from China. Although the preliminary antidumping duty decision was scheduled to be completed by September 14, it was postponed until February 24, 2010, as a result of requests by the petitioner, Resco Products Inc. (U.S. Department of Commerce, International Trade Administration, 2009a, c, d). In December, the ITA made a preliminary determination that subsidies were not being provided to producers and exporters of magnesia-carbon bricks from China, so no duties would be assessed (U.S. Department of Commerce, International Trade Administration, 2009b).

Production

U.S. shipments of caustic-calcined magnesia were 14% lower than those in 2008, and refractory magnesia shipments decreased significantly (table 3). Magnesium hydroxide shipments were about 5% lower than those in 2008. The decrease in magnesium compounds consumption was mainly a result of the economic downturn that had begun at the end of 2008.

Data for magnesium compounds were collected by the U.S. Geological Survey (USGS) from one voluntary survey of U.S. operations. Of the 12 operations canvassed, 92% responded, representing 99% of the magnesium compounds shipped and used, including data for some compounds that were not reportable in table 3. Data for the one nonrespondent were estimated on the basis of prior-year production levels.

The largest capacity magnesite processing facilities in the world are in China and Russia. Together with the United States, these countries accounted for about two-thirds of the world magnesite production capacity. Japan and the United States accounted for about one-half of the world's magnesium compounds production capacity from seawater or brines. Fused magnesia was produced in Australia, Brazil, China, Israel, Japan, the Republic of Korea, Mexico, Russia, the United Kingdom, and the United States. World production capacity for fused magnesia was estimated to be about 560,000 metric tons per year (t/yr), including about 372,000 t/yr of capacity in China (Schroeder, 2006). Fused magnesia was produced by one company in the United States, UCM Group PLC of the United Kingdom, which operated a plant in Cherokee, AL, through its Muscle Shoals Minerals Inc. subsidiary.

Norway has been traditionally the world's principal producer and supplier of olivine, but since 2004, when a new olivine mine was opened in Greenland, Norway's share of world production has dropped to about 30% from about 66%. Other producers include Australia, Austria, Brazil, China, Greece, Italy, Japan, the Republic of Korea, Mexico, Spain, Taiwan, Turkey, and the United States. Roberts (2008) estimated that total world production of olivine in 2008 was 8.4 million metric tons (Mt). Two companies in the United States produced olivine—Unimin Corp. and Olivine Corp. Unimin operated a mine in North Carolina and processing plants in Indiana and North Carolina. Olivine operated one mine and one processing plant in Washington.

In May, Great Salt Lake Minerals Corp. withdrew and refiled a permit application with the U.S. Army Corps of Engineers to build new solar evaporation ponds on the Great Salt Lake. The withdrawn application originally was filed in 2007 to develop 13,400 hectares (ha) on the lake. The new application includes 12,600 ha of the earlier permit application, a separate 2,430-ha legacy lease on the west side of the lake, and 15,400 ha on the northwest arm of the lake that the State of Utah agreed to lease to the company in January in exchange for the company relinquishing undeveloped leases it has held since 1967 on 12,100 ha around Promontory Point. The plan to build new solar evaporation ponds was scheduled to undergo Federal environmental review with the Army Corps of Engineers as the lead agency (Great Salt Lake Minerals Corp., 2009).

Consumption

In 2009, chemical intermediates was the largest tonnage end use for caustic-calcined magnesia, with 40% of the total.

The following categories (with the individual components in descending order of consumption in parentheses) were the other end-use sectors for caustic-calcined magnesia: environmental applications (water treatment and stack-gas scrubbing), 35%, and agriculture (animal feed and fertilizers), 25%. The remaining categories each had less that 1% of the total use—manufacturing (rubber and electrical) and construction (primarily oxychloride and oxysulfate cements).

Magnesium hydroxide was used for water treatment, in medicines and pharmaceuticals, as a chemical intermediate, and in fertilizer (uses are given in descending order of quantity). Magnesium sulfate was used mostly for chemicals, fertilizers, pulp and paper, rubber, pharmaceuticals, and water treatment (in descending order of quantity). Magnesium chloride was used mainly for ice control. Magnesium chloride brines were used for road dust and ice control.

Scientists at the U.S. Department of Energy's (DOE) Berkeley Laboratories created nanocrystals of magnesium oxide that glow blue when exposed to ultraviolet light. The researchers discovered a fundamentally new, unconventional mechanism to control the size of these nanocrystals, unlike traditional growth methods that leave the nanocrystals attached to a substrate. The nanocrystals could be used in applications such as bioimaging or solid-state lighting, but the DOE scientists planned to use them to study mechanisms for carbon sequestration. The minerals that fix magnesium into a stable carbonate are compositionally complex, but the nanocrystals were expected to provide a simple model to mimic this process (Science Daily, 2009).

Foreign Trade

In 2009, exports of magnesite and magnesia were well below those in 2008. Dead-burned magnesia exports were 62% lower than those in 2008, with Canada (67%) as the principal destination. Caustic-calcined magnesia exports were 43% lower than those in 2008. Thailand (70%) was the main destination (table 4).

Imports of caustic-calcined magnesia were 25% lower than those in 2008, and imports of dead-burned magnesia were 61% lower than those in 2008. For both types of magnesia, China was the principal source country (table 6). Although China was the leading import source for dead-burned magnesia, imports from China were 70% less than imports in 2008, probably reflecting the drop in steel production.

Trade data for olivine are not available separately from the U.S. Census Bureau. The Journal of Commerce Port Import/Export Reporting Service (PIERS), however, provides data on material that travels by ship. According to PIERS, U.S. exports of olivine in 2009 were 17 metric tons (t) to Taiwan. U.S. olivine imports were 114 t; 56% came from China and 43% came from India. These data are significantly less than the quantities traditionally reported. Because there is no Harmonized Tariff Schedule number specifically for olivine, some shipments may have been misclassified and cannot be positively identified.

World Review

Australia.—Queensland Magnesia Pty. Ltd. (QMAG) delayed the expansion of its 100,000-t/yr caustic-calcined magnesia plant in Parkhurst, Western Australia, until the second half of 2010. The expansion initially was planned in response to reduced exports from China, particularly to the European Union and the United States. As a result of a significant decline in demand from world steel and refractory markets, QMAG cut production at its Kunwarara Mine and Parkhurst processing plant in Rockhampton. These adjustments began in December 2008 and, as of February 2009, the Kunwarara Mine stopped contract mining activities and the Parkhurst processing plant operated at only 30% of capacity. Production was expected to remain at these levels until the middle of 2009 (Queensland Magnesia Pty. Ltd., 2009).

In October, Beacon Hill Resources Plc acquired Tasmania Magnesite NL, which owned magnesite deposits in northwest Tasmania with measured and inferred resources of 39 Mt of magnesite. In December, Beacon Hill Resources applied for a mining lease for one of the deposits—Arthur River—with a measured resource of 13.2 Mt of magnesite. The lease would be subject to the completion of studies, such as the Development Proposal and Environmental Management Plan, a public consultation process, and other approvals, which the company expected to complete by yearend 2010. If this process was completed on schedule, Beacon Hill Resources planned to begin mine construction in early 2011, with initial production scheduled by yearend 2011 (Regulatory News Service, 2009).

Brazil.—Buschle & Lepper SA, a small seawater magnesia producer, announced that it would double its production capacity to 12,000 t/yr by yearend 2010. The company planned to market its production at Joinville, Santa Catarina, for specialty chemical, cosmetics, food, and pharmaceutical applications (O'Driscoll, 2009b, p. 41).

China.—Because of reduced demand, China canceled its magnesite export licenses for the second half of 2009. The original license quotas were scheduled to be for a total of 1.1 Mt, with 720,000 t issued in the first half of the year; however, only 119,000 t of magnesite was exported in the first 6 months of 2009 (O'Driscoll, 2009b, p. 30).

Greece.—Grecian Magnesite S.A. began a $10.3 million project in April, which was expected to extend the lifetime of the company's Yerakini magnesite mines by at least 20 years. The project, which would install a new processing line that would be capable of recovering fine fractions from mined ore and stockpiles, could beneficiate 220,000 t/yr of magnesite. The new line would enable Grecian Magnesite to use material that was sized at 18 millimeters or smaller from run-of-mine stockpiles that the company has maintained (O'Driscoll, 2009a).

Korea, North.—Swiss firm Quintermina AG reportedly established partnerships with two North Korean magnesite mining companies to export magnesia from their plants to world markets. One, Korea Magnesia Clinker Industry Group, produced mainly dead-burned magnesia from its two mines in Daehung and Ryong Yang, feeding the 1.2-million-metric-ton-per-year calcining plants in Daehung and Tanchon. The second, Sungri Trading Co., produced caustic-calcined magnesia operations in Yanggangdo Province using feed from a magnesite mine in Baek Bae. Quintermina also planned to become a business partner with Korea Magnesia to refit rotary kilns to adapt them for caustic-calcined magnesia production (O'Driscoll, 2009b).

Norway.—In July, North Cape Minerals AS, the leading olivine producer in Norway, with a total mine capacity of 2.4 Mt/yr, announced that it was temporarily suspending operations at two of its three mines—Bryggja and Raubergvik—because of reduced demand for olivine from the steel industry; only the Åheim Mine would remain open. Steinsvik Olivin AS, another olivine producer in Norway, filed for bankruptcy in September, citing reduced sales for the company's product. The company produced olivine since 2004 at a 150,000-t/yr plant and had planned to expand capacity to 250,000 to 300,000 t/yr (Industrial Minerals, 2009b, c).

Saudi Arabia.—Despite sluggish global economic conditions, Saudi Arabian Mining Co. (Ma'aden) announced plans to build a 140,000-t/yr magnesite processing plant in Medina at a cost of $25.3 million, although no timetable was determined. Ma'aden planned to source high-grade magnesite from its Zarghat deposit and produce dead-burned magnesia and other magnesite-based products for agriculture, construction, and fuel additives markets (Industrial Minerals, 2009a).

Turkey.—Trabzon Mining and Metal Corp. expected to have a 100,000-t/yr dead-burned magnesia plant onstream in Askale by the beginning of 2010. Magnesite from the plant would come from the company's nearby Refahiye Mine. Dead-burned magnesia from the plant was expected to be marketed primarily in Ukraine, although the company also targeted markets in Greece, Iran, Romania, and Turkey (O'Driscoll, 2009c).

Outlook

According to the World Steel Association (2010), world crude steel output was 1.22 billion metric tons in 2009, a decrease of 8.0% from that in 2008. Steel production declined in nearly all the major steel-producing regions; however, production in Asia, in particular China and India, showed positive growth in 2009. China's crude steel production in 2009 reached 568 Mt, an increase of 13.5% from that in 2008; China's share of world steel production increased to 47% of the world total in 2009. In contrast, steel production in the United States fell by more than 36% from that in 2008. A sustained increase in steel production in China could lead to more internal consumption of magnesia-based refractories, which could result in less magnesia available for the export market. China, however, has significant magnesite resources, particularly in Liaoning Province, and could continue to develop the magnesite deposits to satisfy domestic and export markets.

Planned closure in 2011 of Exelon Corp.'s coal-fired powerplants in Cromby and Eddyston, PA, was expected to have a significant effect on the consumption of magnesia for flue-gas desulfurization in the United States. These plants were the leading caustic-calcined magnesia-consuming powerplants in the United States, accounting for about 23,000 t/yr of caustic-calcined magnesia supplied by Canadian and United States firms (O'Driscoll, 2010).

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TABLE 1

SALIENT MAGNESIUM COMPOUND STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2005	2006	2007	2008	2009
United States:					
Caustic-calcined and specified magnesias:[2]					
Shipped by producers:[3]					
Quantity	137	133	125	170	147
Value	60,300	60,300	41,100	52,700	42,200
Exports[4]	5	6	4	1	1
Imports for consumption[4]	152	163	134	167	126
Refractory magnesia:					
Shipped by producers:[3]					
Quantity	W	W	W	W	W
Value	W	W	W	W	W
Exports	25	20	22	22	8
Imports for consumption	478	433	437	386	151
World, production of magnesite	15,600 r	15,600 r	16,700 r	18,400 r	19,000 e

e Estimated. r Revised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Excludes caustic-calcined magnesia used in the production of refractory magnesia.

[3] Includes magnesia used by producers.

[4] Caustic-calcined magnesia only.

TABLE 2

U.S. MAGNESIUM COMPOUND PRODUCERS, BY RAW MATERIAL SOURCE, LOCATION, AND PRODUCTION CAPACITY, IN 2009[1]

(Metric tons, MgO equivalent)

Raw material source and producing company	Location	Capacity	Products
Magnesite, Premier Chemicals LLC	Gabbs, NV	140,000	Caustic-calcined magnesia.
Lake brines:			
Great Salt Lake Minerals Corp.	Ogden, UT	185,000	Magnesium chloride and magnesium chloride brines.
Intrepid Wendover-Potash LLC	Wendover, UT	45,000	Magnesium chloride brines.
Well brines, Martin Marietta Magnesia Specialties LLC[2]	Manistee, MI	314,000	Caustic-calcined magnesia, dead-burned magnesia, and magnesium hydroxide.
Seawater:			
Premier Chemicals LLC	Port St. Joe, FL	107,000	Caustic-calcined magnesia and magnesium hydroxide.
South Bay Salt Works	Chula Vista, CA	3,000	Magnesium chloride brines.
SPI Pharma Inc.	Lewes, DE	5,000	Magnesium hydroxide.
Total		799,000	

[1] Data are rounded to no more than three significant digits; may not add to total shown.

[2] In addition to its Michigan plant, Martin Marietta owned a 15,000-metric-ton-per-year-capacity magnesium hydroxide plant in Lenoir City, TN, which used imported magnesite as a raw material.

TABLE 3

U.S. MAGNESIUM COMPOUNDS SHIPPED AND USED[1]

	2008		2009	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Caustic-calcined and specified (USP and technical) magnesias[2]	170,000	$52,700	147,000	$42,200
Magnesium hydroxide [100% $Mg(OH)_2$][2]	180,000	89,800	170,000	104,000
Magnesium sulfate, anhydrous and hydrous	46,700	15,100	40,100	3,650
Refractory magnesia	W	W	W	W

W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Excludes material produced as an intermediate step in the manufacture of other magnesium compounds.

TABLE 4
U.S. EXPORTS OF CRUDE AND PROCESSED MAGNESITE, BY COUNTRY[1]

	2008		2009	
Material and country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Caustic-calcined magnesia:				
China	5	$15	81	$41
France	225	191	--	--
Mexico	144	166	57	29
Netherlands	234	169	--	--
Thailand	6	14	351	178
Other	276 r	224 r	14	48
Total	890	779	503	296
Dead-burned and fused magnesia:				
Canada	14,600	7,410	5,580	3,420
China	88	85	697	517
Germany	552	491	120	113
Hong Kong	376	259	140	114
India	858	475	226	214
Mexico	1,380	810	435	429
Saudi Arabia	210	122	269	149
Taiwan	370	311	40	36
United Kingdom	229	223	57	62
Venezuela	1,310	654	124	144
Other	2,140 r	2,240 r	701	760
Total	22,100	13,100	8,390	5,950
Other magnesia:				
Bahamas, The	1,060	1,020	61	17
Brazil	912	927	858	959
Canada	4,690	3,640	2,600	2,510
France	815	675	1,170	1,050
Germany	1,010	944	798	634
India	448	1,020	275	275
Korea, Republic of	1,620	1,340	1,770	1,420
Mexico	1,440	1,720	1,100	1,360
Netherlands	1,260	965	684	563
Taiwan	1,240	1,140	1,280	1,230
Turkey	670	904	136	178
Other	2,920 r	4,600 r	1,930	3,330
Total	18,100	18,900	12,700	13,500
Crude magnesite:				
Argentina	710	93	43	6
Canada	3,720	669	3,020	499
China	5,570	1,090	205	28
France	2,840	372	2,810	370
Germany	931	123	651	85
Italy	1,720	225	760	84
Netherlands	138	18	945	124
Sweden	1,080	177	--	--
Saudi Arabia	--	--	497	65
United Kingdom	856	115	679	89
Other	3,470 r	468 r	860	128
Total	21,000	3,350	10,500	1,480

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 5
U.S. EXPORTS OF MAGNESIUM COMPOUNDS[1]

Material	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)	Principal destinations, 2009
Magnesium chloride, anhydrous and other	8,180	$8,050	7,780	$5,480	Canada, 84%; Italy, 7%.
Magnesium hydroxide and peroxide	18,400	15,500	19,100	17,500	Canada, 59%; United Kingdom, 9%; Sweden, 8%.
Magnesium sulfate, natural kieserite and epsom salts	103	209	207	311	Mexico, 74%; Canada, 20%.
Magnesium sulfate, other	11,300	5,340	10,600	5,000	Canada, 92%; Mexico, 6%.

[1] Data are rounded to no more than three significant digits.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF CRUDE AND PROCESSED MAGNESITE, BY COUNTRY[1]

Material and country	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)
Caustic-calcined magnesia:				
Australia	--	--	5,070	$1,490
Brazil	15,600	$6,030	15,400	3,770
Canada	21,500	7,480	26,300	11,000
China	126,000	24,900	79,000	21,300
Greece	1,620	731	--	--
Israel	609	173	25	27
Turkey	2,010	1,090	--	--
United Kingdom	--	--	136	140
Total	167,000	40,400	126,000	37,700
Dead-burned and fused magnesia:				
Australia	7,280	9,480	650	250
Austria	31,200	17,600	21,200	12,300
Brazil	722	212	22,200	7,690
China	319,000	136,000	96,900	34,200
Greece	11,200	4,560	101	44
Israel	4,640	12,500	3,530	10,500
Japan	2,540	4,750	2,380	5,060
Mexico	2,310	1,310	1,160	690
Spain	5,780	2,130	2,000	644
Other	1,330 [r]	1,050 [r]	1,160	826
Total	386,000	190,000	151,000	72,200
Other magnesia:				
Brazil	689	821	179	272
Canada	542	187	552	326
China	1,060	2,320	467	760
Israel	569	1,080	374	802
Japan	1,220	3,010	569	1,430
Mexico	8,850	5,740	5,160	3,650
Slovakia	751	228	1,070	370
Other	258	647	361	1,140
Total	13,900	14,000	8,740	8,750
Crude magnesite:				
Brazil	133	148	209	221
China	13,900	3,770	3,330	472
France	32	44	208	184
Israel	1,000	849	1,690	1,580
Japan	426	740	472	1,130
United Kingdom	--	--	176	186
Other	351 [r]	170 [r]	184	59
Total	15,800	5,720	6,270	3,830

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 7

U.S. IMPORTS FOR CONSUMPTION OF MAGNESIUM COMPOUNDS[1]

	2008		2009		
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Principal sources, 2009
Magnesium chloride, anhydrous and other	71,400	$15,900	88,000	$21,500	Israel, 68%; Netherlands, 28%.
Magnesium hydroxide and peroxide	7,310	16,500 [r]	2,930	6,440	Israel, 35%; Netherlands, 13%; Japan, 11%.
Magnesium sulfate, natural epsom salts	528	202	1,740	378	China, 78%; India, 14%.
Magnesium sulfate, natural kieserite	51,100	1,100	25,800	574	Germany, 100%.
Magnesium sulfate, other	31,200	15,000	15,000	9,660	China, 34%; Germany, 31%; Mexico, 22%.

[r] Revised.

[1] Data are rounded to no more than three significant digits.

Source: U.S. Census Bureau.

TABLE 8

WORLD MAGNESIUM COMPOUNDS ANNUAL PRODUCTION CAPACITY, DECEMBER 31, 2009[1, 2]

(Thousand metric tons, MgO equivalent)

	Raw material				
	Magnesite		Seawater or brines		
Country	Caustic-calcined	Dead-burned	Caustic-calcined	Dead-burned	Total
Australia	78	120	--	--	198
Austria	70	405	--	--	475
Brazil	60	326	6	--	392
Canada	50	--	--	--	50
China	430	2,270	--	10	2,710
France	--	--	30	--	30
Greece	120	100	--	--	220
India	20	202	--	--	222
Iran	50	40	--	--	90
Ireland	--	--	--	90	90
Israel	--	--	10	60	70
Italy	25	--	--	--	25
Japan	--	--	55	200	255
Jordan	--	--	10	50	60
Korea, North	20	100	--	--	120
Korea, Republic of	--	--	--	40	40
Mexico	--	--	15	95	110
Netherlands	--	--	10	165	175
Norway	--	--	25	--	25
Poland	--	10	--	--	10
Russia	100	2,400	--	--	2,500
Serbia	--	40	--	--	40
Slovakia	--	465	--	--	465
South Africa	12	--	--	--	12
Spain	140	70	--	--	210
Turkey	20	404	--	--	424
Ukraine	--	120	20	80	220
United States	140	--	191	195	526
Total	1,340	7,070	372	985	9,760

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes capacity at operating plants, as well as at plants on standby basis.

TABLE 9
MAGNESITE: WORLD PRODUCTION, BY COUNTRY[1,2]

(Metric tons)

Country	2005	2006	2007	2008	2009[e]
Australia	474,000	446,000	447,000	126,000 [r]	200,000
Austria, crude	693,754	769,188	811,556	837,476 [r]	800,000
Brazil, beneficiated	386,759	382,718	399,314	399,320 [r]	400,000 [p]
Canada[e,3]	180,000	180,000	180,000	180,000	180,000
China[e]	6,600,000	6,700,000	8,000,000	10,000,000	11,000,000
Colombia[e]	38,000	40,000	42,000	38,000 [r,e]	35,000
Greece, crude	475,670	463,277	351,414	361,165 [r]	325,000
Guatemala	5,636	1,084	7,612	11,758	17,247 [4]
India[e]	380,000	370,000	360,000	350,000	340,000
Iran	114,708 [4]	110,000	110,000	110,000	110,000
Korea, North[e]	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000
Pakistan	3,029	1,884	1,400 [e]	1,600 [e]	1,700
Poland, concentrate	55,300 [r]	62,500 [r]	65,000	65,000 [e]	65,000
Russia[e]	1,100,000	1,200,000	1,200,000	1,200,000	1,000,000
Serbia, crude[e]	20,000 [5]	20,000	20,000	20,000	20,000
Slovakia, concentrate	920,000 [r]	941,000 [r]	957,000 [r]	807,000 [r]	800,000
South Africa	54,800	73,300	80,700	83,900 [r]	80,000
Spain	556,129	539,239	461,901	460,000 [e]	460,000
Turkey, run-of-mine	2,372,206	2,088,033	1,984,908 [r]	2,143,047 [r]	2,000,000
United States	W	W	W	W	W
Zimbabwe	893	939	2,000 [e]	2,000 [e]	1,000
Total	15,600,000 [r]	15,600,000 [r]	16,700,000 [r]	18,400,000 [r]	19,000,000

[e] Estimated. [p] Preliminary. [r] Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total."

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Figures represent crude salable magnesite. In addition to the countries listed, Bulgaria produced magnesite, but output is not reported quantitatively, and available information is inadequate for formation of reliable estimates of output levels. Table includes data available through May 12, 2010.

[3] Magnesitic dolomite and brucite.

[4] Reported figure.

[5] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

MANGANESE

By Lisa A. Corathers

Domestic survey data and tables were prepared by Connie Lopez, statistical assistant, and the world production tables were prepared by Glenn J. Wallace, international data coordinator.

In 2009, U.S. manganese apparent consumption was an estimated 445,000 metric tons (t), a 47% decrease from the revised amount of 844,000 t in 2008 (table 1). Decreases in imports of manganese dioxide, manganese ferroalloys, manganese metal, and manganese ore, as well as decreases in high-carbon ferromanganese shipments from the U.S. Government's National Defense Stockpile (NDS), accounted for the decline in apparent consumption.

Manganese imports (table 6) decreased by 58% on a content basis to 395,000 t compared with those of 2008, based on U.S. Census data for manganese ore, ferromanganese, and silicomanganese, and the stochiometric ratios for manganese dioxide and manganese metal. Manganese exports (table 5) decreased by 19% to 47,600 t compared with those of 2008, based on the typical manganese contents of the materials as calculated in table 4.

In 2009, the annual average domestic price of ore decreased by 46% from that in 2008, and the average prices of manganese ferroalloys and manganese metal fell. The annual international benchmark price of metallurgical-grade ore decreased by 51%, based on monthly contract prices between Australian producers and Japanese consumers in 2009. Average U.S. spot-market prices for high- and medium-carbon ferromanganese and silicomanganese decreased from those in 2008 by 56%, 53%, and 50%, respectively. The average spot market price for manganese metal decreased by 29% from that in 2008.

Only high-carbon ferromanganese remained in NDS physical inventory at yearend 2009. Sales of manganese materials from the NDS in 2009 reduced the Government's inventory of manganese by 8% (content basis), leaving an inventory that was three times more than the amount of high-carbon ferromanganese reported consumed on a contained-weight basis in 2009.

World production of manganese ore in 2009 decreased by 12% on a gross weight basis and by 16% on a contained-weight basis, compared with that in 2008 (table 7). China was the leading producer on a gross-weight and contained-weight basis. Combined world production of ferromanganese and silicomanganese decreased by 8% to 12.5 million metric tons (Mt) on a gross weight basis compared with the revised amount in 2008 (table 8). China was the leading producer of these manganese ferroalloys.

Manganese is essential to iron and steel production by virtue of its sulfur-fixing, deoxidizing, and alloying properties. Steelmaking, including its ironmaking component, accounted for most of the reported domestic manganese consumption, currently in the range of 77% to 90% of U.S. apparent consumption. Among a variety of other uses, manganese is a key component of certain widely used aluminum alloys and is used in oxide form in dry cell batteries.

Legislation and Government Programs

Air Quality, Emissions Limits.—The U.S. Environmental Protection Agency (EPA) issued final national emission standards for hazardous air pollutants (HAPs) for the chemical preparations industry, excluding manufacturers of indelible ink, India ink, stamp pad ink, and writing ink. The EPA used particulate matter as a surrogate limit for the target metal HAPs (metal compounds of chromium, lead, manganese, and nickel). Emission limits varied depending on whether the sources were existing or new (U.S. Environmental Protection Agency, 2009b).

Air Quality, Mandatory Reporting of Greenhouse Gas Emissions.—EPA issued a final rule that requires monitoring and reporting of greenhouse gas emissions that exceed certain thresholds from all sectors of the economy, including manganese ferroalloy manufacturers (U.S. Environmental Protection Agency, 2009a, p. 56260).

Air Quality, Public Health Study.—In July, the Agency for Toxic Substances and Disease Registry (ATSDR) of the U.S. Department of Health and Human Services reported the results of its air investigation in the Marietta, OH, area. The ATSDR conducted air sampling from April 2007 to March 2008 to determine potential health impacts from air emissions around the former Union Carbide facility complex near Marietta, OH. The complex is currently occupied by Chevron-Phillips Chemical Company, Eramet Marietta Inc., Eveready Battery Co., and Solvay Advanced Polymers. The ATSDR found that manganese was the only metal that exceeded background levels and ATSDR and EPA health-based guidelines. The ATSDR identified a gap in scientific knowledge regarding the effect of chronic, low-level manganese exposures on general populations. The ATSDR recommended that additional sampling and analysis ("source fingerprinting") be conducted to determine the relative effects of potential area sources of manganese. They expected to evaluate the findings from the planned EPA-funded health study later in 2009 (Agency for Toxic Substances and Disease Registry, 2009, p. 2, 16).

Stockpile.—The Annual Materials Plan (AMP) for fiscal year 2009 that the Defense National Stockpile Center (DNSC) of the Defense Logistics Agency issued on October 3, 2008, covered the period from October 1, 2008, through September 30, 2009. Under this AMP, the maximum disposal authority for manganese materials was 226,796 t for metallurgical-grade ore and 90,718 t for high-carbon ferromanganese (Defense National Stockpile Center, 2008). The maximum disposal authority under an AMP is the maximum quantity of material that may be disposed in a given fiscal year as authorized by Congress; these may differ from the disposal authority quantities listed in table 2.

For calendar year 2009, the DNSC disposed (sold) 33,566 t of high-carbon ferromanganese. Only high-carbon ferromanganese remained in NDS physical inventory at yearend (403,000 t, gross weight). The estimated manganese content of this material was 302,000 t, which was 8% less than the amount contained at yearend 2008.

The U.S. Department of Defense (DOD) was directed by Congress to review its current policy for disposal of NDS material. A DOD working group concluded that DNSC's current disposal policy required revision and that the NDS should be reconfigured into a Strategic Material Security Program to encompass a full range of responsibilities required to develop an integrated and comprehensive approach to strategic materials management. The working group supported DNSC's recommendation to temporarily suspend or limit the sale of 13 materials that had no viable substitutes and on which the United States was wholly or substantially import dependent or at a significant risk of supply disruption. Sales of ferromanganese were curtailed to hold a goal quantity equivalent to 1 year's AMP (U.S. Department of Defense, 2010, p. 1–2).

Exploration and Development

Rocher Deboule Minerals Corp., White Rock, British Columbia, Canada (now American Manganese Inc.) completed a NI 43-101 Resource Study Estimate and a NI 43-101 Preliminary Economic Assessment of its Artillery Peak manganese project, Mohave County, AZ. Indicated resources were 10.9 Mt at an average grade of 4.46% manganese and inferred resources were 96.9 Mt at an average grade of 4.52%. According to the preliminary economic assessment, the area can be mined by conventional open pit methods at a rate of 3,500 metric tons per day for 17 years. About 50,000 tons per year (t/yr) of electrolytic manganese metal would be produced using a patent-pending sulfurous acid-leach process followed by conventional electrolysis (Rocher Deboule Minerals Corp., 2009).

Production

Ore and Concentrate.—The only mine production of manganese in the United States consisted of small amounts of manganiferous material having a natural manganese content of less than 5%. This material was produced in South Carolina for use in coloring brick.

Chemicals, Ferroalloys, and Metal.—Production statistics for these materials were concealed to avoid disclosing company proprietary data. Domestic producers of manganese ferroalloys, metal, and synthetic dioxide are listed in table 3.

The global financial problems that began during the third quarter of 2008 affected the largest domestic producers of manganese materials to a varying extent in 2009. At its Marietta, OH, ferroalloys plant, Eramet Marietta Inc. curtailed operation of its No. 1 silicomanganese furnace from March through May and curtailed operation of the No. 12 high-carbon ferromanganese furnace throughout the year. As a result, the company laid off 110 workers (Metal-Pages, 2009e; Eramet SA, 2010, p. 11). However, Felman Production Inc. was able to produce silicomanganese steadily throughout the year in its three electric arc furnaces, with a production level at about 9,100 metric tons per month (t/mo) (Metal-Pages, 2009i).

To supplement its high-carbon ferromanganese supply, Eramet Marietta purchased some of the 27,200 t of ferromanganese sold by the DNSC in October (Defense National Stockpile Center, 2009). In November, Eramet Marietta secured an electric power arrangement through 2018 with the Columbus Southern Power division of American Electric Power-Ohio. As part of the arrangement, Eramet Marietta agreed to maintain on average a minimum of 200 employees per year, and to make a $40 million capital investment in plant operations. The first $20 million investment would be made by yearend 2011 and the other $20 million by yearend 2014 (Metal-Pages, 2009f).

Tronox Incorporated voluntarily filed Chapter 11 bankruptcy for its U.S.-based operations, including its electrolytic manganese dioxide (EMD) facility in Henderson, NV. The decision to file was made to address environmental and litigation legacy liabilities that were incurred when the company was spun off from Kerr-McGee Corporation in 2006. The company planned to continue operations without interruption (Tronox Incorporated, 2009).

Bateman Mineral Recovery started full operations of its Riders ferromanganese-slag recovery plant in late May 2009 in Johnstown, PA. The Riders plant was designed to recover 500 t/mo of high-carbon ferromanganese from 25,000 t/mo of stockpiled blast-furnace slag produced by ArcelorMittal's (formerly Bethlehem Steel Corp.) Johnstown steel operations. The recovered ferromanganese was to be sold to the steel industry and the crushed slag to the aggregate market, possibly for use in acid mine water treatment (Bateman Mineral Recovery, 2008; Louis Eybers, general manager, Jigging Technologies LLC, unpub. data, March 25, 2010).

Consumption, Uses, and Stocks

Data relating to manganese end use and other information have shown that metallurgical applications account for most domestic manganese consumption, 85% to 90% of which has been for steelmaking. In 2009, reported U.S. ore consumption indicated that unit consumption of manganese in ironmaking, which could not be published to avoid disclosing company proprietary data, was about the same as that of 2008 and remained a relatively minor component of overall manganese use in steelmaking. Reported consumption (gross weight) of manganese metal, ferromanganese, and silicomanganese decreased by 36%, 20%, and 17%, respectively, from that in 2008 (table 4). Because of incomplete reporting to the U.S. Geological Survey (USGS) voluntary consumption survey, the figures in this table represent relative rather than absolute quantities.

The combination of the indicated consumption pattern with estimates of apparent consumption, on a gross weight basis, suggested that manganese alloy unit consumption in steelmaking was about 4.7 kilograms per metric ton (kg/t) or about 1.14 times that calculated on the basis of reported consumption in

2009. This level was 38% less than the revised quantity of 7.5 kg/t estimated for 2008 and was a result of a significant decrease in ferromanganese and silicomanganese apparent consumption. The decrease in the apparent consumption of these two ferroalloys was attributable to significant decreases in ferromanganese and silicomanganese imports.

Relatively small quantities of manganese were used for alloying with nonferrous metals, chiefly in the aluminum industry as manganese-aluminum briquettes that typically contained either 75% or 85% manganese. Manganese plays an important alloying role in aluminum to increase corrosion resistance. The most important use of aluminum-manganese alloys is in the manufacture of soft drink cans. Other uses include, but are not limited to, aircraft, automobiles, cookware, radiators, and roofing (Roskill Information Services Ltd., 2008, p. 195–200).

Comparatively small amounts of manganese were used domestically in animal feed, brick coloring, dry cell batteries, fertilizers, and manganese chemicals. These were among the many nonmetallurgical applications of manganese (Roskill Information Services Ltd., 2008, p. 206–229). The source of manganese units for these applications was mainly manganese ore.

In 2009, reported domestic consumption of manganese ore decreased by 9% to 422,000 t, while corresponding yearend stocks decreased by 55% to 115,000 t compared with the revised amounts in 2008 (table 1). Apparent consumption of manganese ore on a gross-weight basis in 2009 was about 408,000 t, which excluded any manganese ore consumed directly by ironmaking and steelmaking plants. The USGS must exclude reporting by these operations to avoid disclosing company proprietary information. The discrepancy between apparent and reported consumption represented incomplete reporting to the USGS voluntary consumption survey.

Data on domestic consumption of manganese ore, exclusive of that consumed by the steel industry, are collected by means of the "Manganese Ore and Products" survey. In 2009, nine firms were canvassed that process ore or had processed ore in the past by such methods as grinding and roasting, or that consume it in the manufacture of dry cell batteries and manganese chemicals, ferroalloys, and metals. Of those nine companies, all consumed manganese ore in their processes in 2009. The collective consumption of these firms was considered to constitute all the manganese ore consumption in the United States, exclusive of that consumed by the steel industry. Full-year responses or a basis upon which to estimate the data were obtained from all of these firms for 2009.

Prices

There were significant decreases in annual average manganese material prices in 2009 from those in 2008 because of continued effects of the economic downturn that began during the third quarter of 2008.

Manganese Ore.—The USGS estimated the annual U.S. average contract price of metallurgical-grade ore containing 48% manganese was $6.61 per metric ton unit (mtu). This was a 46% decrease compared with that in 2008, which followed the 51% decrease in the annual average international benchmark price for this grade of ore, as calculated from monthly contract prices set between Japanese consumers and Australian producers (Australian Bureau of Agricultural and Resource Economics and Sciences, unpub. data, January through December, 2009). Prices were above or below this value, depending on ore quality, time of year, and nature of transaction. The year-average spot market price for this grade of ore based on weekly averages of Chinese cost and freight (CNF) transaction prices as reported by Ryan's Notes was $5.61 per mtu. The range in CNF spot market prices per mtu peaked in January at $8.00 to $8.50, fell to a low of $4.00 to $4.25 in mid-year, then rose to finish the year at $6.85 to $7.10 per mtu because of improved market conditions. The price of a metric ton of ore (gross weight) is obtained by multiplying the mtu price by the percentage manganese content of the ore; for example, by 48 when the manganese content is 48%. The ore market consisted of a number of submarkets because of differences in ore-quality requirements by end use ferroalloy production, blast furnace ironmaking, and manufacture of manganese chemicals.

Manganese Ferroalloys and Metal.—Prices for manganese ferroalloys tend to vary in response to changes in demand by the steel and ferrous foundry industries, while those of manganese metal predominantly follow changes in demand by the aluminum industry. Manganese ferroalloy prices are also influenced by changes in the product mix of the world's suppliers because different manganese ferroalloys are largely interchangeable with each other.

Annual average import prices for manganese ferroalloys are given by Platts Metals Week. These prices are based on free market spot prices per unit of measurement, f.o.b. Chicago, IL, or Pittsburgh, PA, warehouse. Annual average import prices were $1,208.16 per gross ton for high-carbon ferromanganese, 100.52 cents per pound for medium-carbon ferromanganese, and 50.72 cents per pound for silicomanganese. These prices were 56%, 53%, and 50% lower, respectively, than those of 2008 when they reached an alltime high. The annual average price for manganese metal is based on weekly averages of North American transaction prices published by Ryan's Notes for bulk shipments of manganese metal, f.o.b. Chicago, IL, or Pittsburgh, PA, warehouse. The annual average North American transaction price for manganese metal was 140.13 cents per pound, which was a 20% decrease compared with that of 2008. The year-average price for manganese metal was 22% more than the last listed U.S. price for domestically produced electrolytic manganese metal of $1.15 per pound at the beginning of 1996.

According to Platts Metals Week, the price range for high-carbon ferromanganese containing 78% manganese, per gross ton, began the year at $1,375 to $1,400 and ended the year at $1,310 to $1,350, for a net decrease of 4%. The price range, per pound of manganese, for medium-carbon ferromanganese with a manganese content of 80% to 85% and a nominal carbon content of 1.5% began the year at 120 to 140 cents and ended the year at 100 to 105 cents, for a net decrease of 21%. The price range, per pound of alloy, for imported silicomanganese with 2% carbon started the year at 44 to 49 cents and ended 2009 at 58 to 62 cents, for a net increase of 29%. This net price increase was caused by low levels of inventory and slight improvement in domestic steel production at yearend.

According to Ryan's Notes North American transaction prices, the 2009 yearend price range of bulk manganese metal shipments was 142 to 150 cents per pound, a net increase of 4% from the price of 135 to 145 cents per pound at the beginning of the year. This net price increase was attributable to rising aluminum production in the fourth quarter of 2009.

Foreign Trade

In the absence of domestic mine production and recycling for manganese, U.S. net import reliance, as a percentage of apparent consumption, was 100% for manganese, the same as it has been for the past 24 years. The ensuing comparisons of foreign trade data were made on the basis of gross weight.

In 2009, U.S. exports of ferromanganese and silicomanganese increased, while exports of manganese dioxide, manganese metal, and manganese ore decreased compared with exports of these materials for 2008 (table 5). The biggest year-to-year changes in exports was that of manganese ore, which were 68% lower than those in 2008. Canada accounted for 91% of manganese ore exports, followed by Germany with 4%.

In 2009, U.S. imports of potassium permanganate increased compared with those of 2008, while imports of ferromanganese, manganese dioxide, manganese metal, manganese ore, and silicomanganese fell (table 6). The most significant year-to-year change was for imports of manganese ore; these were 53% less than those of 2008. Decreases in this import category were especially notable for Gabon, with a decrease of about 170,000 t (48%), Australia, with a decrease of 66,900 t (65%), and Brazil, with a decrease of 65,300 t (96%) year-on-year.

Imports of spiegeleisen (pig iron containing about 20% manganese) from South Africa decreased to less than 1 t in 2009 from 1 t in 2008, on a gross weight basis. The 2009 customs value for spiegeleisen imports was $300,653 (U.S. Census Bureau, unpub. data, December 2009).

Antidumping Duty Administrative Reviews.—No final antidumping duty rates were assessed in 2009 on imports of manganese materials to the United States.

U.S.-World Trade Organization (WTO) Chinese Raw Material Export Dispute Settlement Proceedings.—On June 23, the United States requested consultations with China and the WTO Dispute Settlement Body (DSB) about curbs placed by China on exports of various materials, including manganese metal and ore. In July, Canada, the European Union, Mexico, and Turkey requested to join the consultations. On November 4, the Office of the United States Trade Representative requested that the DSB establish a dispute settlement panel to review the U.S. claims. (The European Union and Mexico also requested the establishment of a dispute settlement panel.) The DSB established a single panel on December 21 and appointed panel representatives on March 29, 2010. The panel was expected to finalize the proceedings in April 2011 (Office of the United States Trade Representative, 2009; World Trade Organization Dispute Settlement Body, 2010).

World Industry Structure

World manganese ore production was estimated by the USGS at 10.8 Mt (contained manganese) in 2009, down 16% from the revised amount in 2008. Most (97%) of manganese ore was produced in 10 countries. On a manganese-content basis, the leading producer countries of manganese ore were, in decreasing order, China (22%), Australia (20%), South Africa (18%), India (9%), and Gabon (8%) (table 7). World manganese ferroalloy production in 2009 was 12.5 Mt (gross weight), an 8% decrease from that of 2008. On a gross weight basis, the leading producer countries of manganese ferroalloys were, in decreasing order, China (64%), India (12%), Ukraine (7%), Japan (3%), Norway (3%), and South Africa (3%) (table 8).

The International Manganese Institute (IMnI) estimated that world apparent consumption of manganese ferroalloys decreased by 12% to 12.0 Mt in 2009 compared with that of 2008. Of that amount, 7.2 Mt was silicomanganese, 4.0 Mt was high-carbon ferromanganese, and 0.8 Mt was refined (medium- and low-carbon) ferromanganese. IMnI estimated that world production of manganese ferroalloys was 11.6 Mt, slightly less than world consumption. World manganese ore production was 11.1 Mt (contained manganese), which was a decrease of about 22% from the revised IMnI estimate of 14.3 Mt in 2008 (Ideas 1st Information Services Pvt. Ltd., 2010, p. 19; Mark Camaj, market analyst, International Manganese Institute, unpub. data, June 13, 2010).

New manganese materials projects scheduled for completion around the world from 2009 through 2013 are listed in table 9.

World Review

European Union.—Antidumping duties on silicomanganese imported from China (8.2%) and Kazakhstan (6.5%) that had been previously suspended by the Commission of the European Communities in 2007 and 2008 automatically went into effect on September 7 (Metal-Pages, 2009g).

Australia.—OM Holdings Limited (Singapore) constructed a secondary processing plant (SPP) to crush and reprocess reject material from the heavy-media drum plant at the Bootu Creek Manganese Mine. The SPP operations would first handle reject material currently stockpiled (about 1.5 Mt) with a tie-in to the existing heavy-media drum plant to follow. SPP material would serve as feedstock to sinter plant operations; the company expected the SPP to initially generate an additional 150,000 t/yr of 35% manganese fines
(OM Holdings Limited, 2009a, 2010).

Brazil.—Vale S.A. (formerly Companhia Vale do Rio Doce) was the leading manganese ore and ferroalloy producer in Brazil. Vale produced 1.7 Mt of manganese ore in 2009, a decrease of 30% from that of 2008. The Azul Mine in the Carajás region produced 1.4 Mt of ore. Vale's manganese ferroalloys plants, with the exception of the Urucum plant, resumed operation at the beginning of 2009 after being shut down in December 2008. Vale's manganese alloy production in Brazil was 99,000 t, a 66% decrease from that in 2008 (Ryan's Notes, 2009b; Vale S.A., 2010, p. 4).

China.—Chinese imports of manganese ore were at an alltime high of 9.62 Mt (gross weight) in 2009, up 27% from that of 2008 (TEX Report, The, 2010a). This was about 29% of the USGS estimated total world production (gross weight) in 2009. Most of the imported manganese ore was likely used to blend with lower-grade domestic manganese ore for the production of manganese ferroalloys and metal.

China was the leading producer of manganese ferroalloys in the world but still relied on imports of ferromanganese and silicomanganese. The country's manganese ferroalloy exports were significantly less in 2009 than in 2008—47,062 t (-87%) of ferromanganese and 115,175 t (-84%) of silicomanganese (TEX Report, The, 2010b).

China, the leading producer of electrolytic manganese metal (EMM) in the world with about 190 companies, produced 1.29 Mt of EMM in 2009, an increase of 14% from the revised amount of 1.13 Mt in 2008. The country exported about 155,000 t of EMM in 2009, a decrease of 50% from that in 2008. Before the global economic downturn in late 2008, China exported between 250,000 t/yr and 300,000 t/yr of EMM. Only two countries, China and South Africa, have the capacity to produce EMM. China's EMM capacity in 2009 was estimated to be about 2.11 million metric tons per year, or 96% of the world total (2.20 Mt) (Metal-Pages, 2009c; Tan, 2010).

In 2009, China was also the leading producer of EMD in the world, with total output of 181,520 t. This equated to 79% of the country's annual production capacity, which was 230,000 t. China's share of the active world EMD production capacity in 2009 was about 60%, followed by the United States with 16%. China's EMD exports fell slightly to 38,720 t from that of 2008, owing mainly to antidumping duties assessed by Japan and the United States (Li, 2010, p. 2, 5–7).

Several Central Government policies affected manganese materials during the year. The Government maintained the 20% export duty on ferromanganese, unwrought manganese metal, and silicomanganese exports. They also kept the duty on manganese ore exports at 15%. However, they raised the value-added tax on manganese ore imports to 17% from 13% (Metal-Pages, 2009d; TEX Report, The, 2009).

France.—Eramet reported a 13% reduction in worldwide manganese alloy output in 2009 to 617,000 compared with that in 2008. The company owned manganese alloy plants in China, France, Norway, and the United States (Eramet SA, 2010, p. 33). Vale's Rio Doce Manganese Europe reduced manganese alloy production at its Dunkerque plant by 18% to 45,000 t in 2009 from that in 2008 (Vale S.A., 2010, p. 4).

Japan.—Nippon Mining & Metals Co., Ltd. started a demonstration-scale recycling plant for used lithium-ion batteries to extract value-bearing metals such as cobalt, lithium, manganese, and nickel. The plant, located on the premises of Nikko Tsuruga Recycle Co., Ltd. in Fukui, was expected to recover about 6 t/mo of manganese. Full-scale commercial operation of the plant, which would be the first of its kind, was planned for 2011 (Nippon Mining & Metals Co., Ltd., 2009).

Mexico.—Minera Autlán, S.A.B. de C.V., the sole Mexican manganese ferroalloys manufacturer, reported a 40% decrease in manganese ferroalloys production in 2009 compared with that in 2008 (table 8). However, as global market conditions improved during the second half of 2009, the company restarted two of its plants—Teziutlan in June and Gomez Palacio in September—after having shut them down at yearend 2008. Additionally, the company operated its Tamós ferroalloys plant below full capacity (estimated to be about 150,000 t/yr) (Minera Autlán, S.A.B. de C.V., 2010, p. 12).

Norway.—Manganese ferroalloy production at Vale's Mo I Rana plant was 79,000 t, a 29% decrease from that of 2008. The decrease in production was attributable to the maintenance of one of two furnaces starting in November (Vale, S.A., 2010, p. 4). Eramet increased its ownership stake to 100% from 56% in Eralloys, a company combining the former silicomanganese producer Tinfos AS. Tinfos produced silicomanganese at its Kvinesdal plant, which has an 180,000-t/yr production capacity (Eramet, SA, 2010, p. 33).

South Africa.—The global economic slowdown greatly affected production of manganese materials in 2009. South Africa's position as the world's leading producer of manganese ore (content-basis) in 2008 dropped to third in 2009. The country became the sixth-leading producer of manganese ferroalloys (gross-weight basis) in 2009, down from third in 2008.

Samancor Manganese reduced production at its Metalloys manganese ferroalloy plant in FY 2009 (July 1, 2008, through June 30, 2009). The plant produced 301,000 t of manganese alloys during that period or about 53% of its total annual production capacity (BHP Billiton Ltd., 2009, p. 59, 61). In March, Mogale Alloys Limited curtailed two silicomanganese furnaces capable of producing about 4,000 t/mo (Ryan's Notes, 2009a). In April, Assmang Ltd. shut down its No. 5 high-carbon ferromanganese furnace (55,000-t/yr production capacity) at its Cato Ridge Works plant in KwaZulu Natal. High-carbon ferromanganese furnaces Nos. 3 and 4 that were shut down at yearend 2008 remained closed, owing to market conditions, as was the refined ferromanganese alloys convertor at the company's Cato Ridge Alloys plant. As a result, Cato Ridge operated at about 65% of its total capacity (225,000 t/yr) throughout most of the year (Assore Limited, 2009; Metal-Pages, 2009a, b).

There were ownership changes in several South African manganese companies. In May, Ruukki Group Plc (Finland) acquired 84.9% of Mogale. The minority stake in Mogale would be owned by South African Black Economic Empowerment (BEE) partners. During the year, Mogale produced ferrochromium, silicomanganese, and stainless steel; the production capacity for this mix of materials was 110,000 t/yr (GlobeNewswire, Inc., 2009; Ruukki Group Plc, 2010, p. 11). In July, Samancor Manganese sold 26% of the Hotazel manganese mines—Mamatwan and Wessels Mines—to BEE partners (BHP Billiton Ltd., 2009, p. 58). In November, OM Holdings Limited (Singapore) acquired 26% in Ntsimbintle Mining (Proprietary) Limited, which owns 50.1% of the Tshipi Kalahari Manganese Project (OM Holdings Limited, 2009b).

Spain.—Grupo FerroAtlántica, S.L. cut production at all its Spanish manganese ferroalloy operations by 70%. The company's Spanish production capacity was 183,000 t/yr for ferromanganese and 218,000 t/yr for silicomanganese (Metal-Pages, 2009h; Grupo FerroAtlántica, S.L., 2010).

Ukraine.—Ukraine's total output of manganese concentrate decreased by 36% in 2009 to 932,000 t, compared with that of 2008. Manganese ferroalloy production also decreased in 2009 by 64% for ferromanganese and 23% for silicomanganese. However, ferroalloy companies ramped up production in the second and third quarters of 2009, as economic market conditions improved. OAO Zaporozhsky Ferro-Alloy Works restarted five ferroalloy furnaces in June, raising the number of working furnaces to 20 of 31. Nikopol Ferroalloy Plant restarted two silicomanganese furnaces in July after a shutdown of 8 months (Platts Metals Week, 2009a, b).

Outlook

The trend of domestic and global consumption for manganese is expected to follow closely that of steel production, for which the annual growth rate has been typically in the range of 1% to 2% in the United States. Although growth rates for some nonmetallurgical components of manganese consumption, especially batteries, may be higher than for steel production, this situation should have only a minor effect on overall manganese demand.

Details of the outlook for the steel industry are discussed in the Outlook section of the Iron and Steel chapter of the 2009 USGS Minerals Yearbook, volume I, Metals and Minerals. According to the World Steel Association (2009), raw steel production, compared with that in 2008, decreased by 36.4% to 58.1 Mt in the United States while decreasing 8% worldwide to 1,220 Mt. However, raw steel production in China, the leading world producer of raw steel, increased by 13.5% to about 568 Mt. MEPS (International) Ltd. (2010) forecast world raw steel production would increase to 1.4 billion metric tons in 2010 from that in 2009, with a 21% increase in North American raw steel production to 100.5 Mt.

Manganese metal is used primarily by the aluminum industry followed by the steel industry. The outlook for the aluminum industry is discussed in the Outlook section of the Aluminum chapter of the 2009 USGS Minerals Yearbook, volume I, Metals and Minerals.

EMD is used by the primary and secondary battery industries. As a rough indicator of future EMD consumption, U.S. sales of primary and secondary batteries was projected to increase by 2% annually through 2012 to $16.4 billion. Primary battery sales were forecast to rise faster than those of secondary batteries, owing in part to the growing need for replacement primary batteries in portable devices. Sales of secondary batteries were expected to increase at an annual rate of 1.5% through 2012. The value of global primary and secondary battery consumption was forecast to increase by 4.8% annually through 2014 to $109 billion, with U.S consumption below the global average rate (Freedonia Group, Inc., The, 2009, 2010).

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United Nations commodity trade statistics.

TABLE 1
SALIENT MANGANESE STATISTICS[1]

(Thousand metric tons, gross weight, unless otherwise specified)

	2005	2006	2007	2008	2009
United States:					
Manganese ore (20%[r] or more Mn):					
Exports	13	2	29	48	15
Imports for consumption	656	572	602	571	269
Consumption[2]	368	365	351	464 [r]	422
Stocks, December 31, consumers[2]	337	153	190	255 [r]	115
Ferromanganese:					
Exports	14	22	29	23	24
Imports for consumption	255	358	315	448	157
Consumption	286	297	272	304	242
Stocks, December 31, consumers and producers	30	31	31 [r]	27 [r]	31
Consumption, apparent, manganese content[3]	773	1,060	979 [r]	844 [r]	445
Ore price, c.i.f.[4] U.S. ports, dollars per metric ton unit	4.39	3.22	3.10	12.15	6.61
World, production of manganese ore	31,000	33,200 [r]	35,100 [r]	38,100 [r]	33,600

[r] Revised.

[1] Data are rounded to no more than three significant digits.

[2] Exclusive of iron and steel plants.

[3] Based on estimates of average content for all significant components except imports, for which content is reported.

[4] Cost, insurance, and freight.

TABLE 2
U.S. GOVERNMENT DISPOSAL AUTHORITIES AND INVENTORIES FOR MANGANESE MATERIALS AS OF YEAREND 2009[1]

(Metric tons, gross weight)

		Physical inventory[e]				
Material	Disposal authority	Stockpile grade	Uncommitted Nonstockpile grade	Total	Sold, pending shipment	Grand total
Metallurgical ore	2,420	--	(8,910) [2]	(8,910)	XX	(8,910)
High-carbon	436,000	403,000	--	403,000	33,700	436,000

[e] Estimated. XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Negative inventory, as reported by the Defense National Stockpile Center.

Source: Defense National Stockpile Center.

TABLE 3
DOMESTIC PRODUCERS OF MANGANESE PRODUCTS IN 2009

Company	Plant location	Products[1] FeMn	SiMn	MnO_2	Type of process
Energizer Holdings, Inc., Eveready Battery Co.	Marietta, OH			X	Electrolytic.
Erachem Comilog	Baltimore, MD			X	Chemical.
Do.	New Johnsonville, TN			X	Electrolytic.
Eramet Marietta Inc.	Marietta, OH	X	X		Electric furnace.
Felman Productions Inc.	Letart, WV		X		Do.
Tronox LLC	Henderson, NV			X	Electrolytic.

Do. Ditto.

[1] FeMn, ferromanganese; SiMn, silicomanganese; MnO_2, synthetic manganese dioxide.

TABLE 4
U.S. CONSUMPTION, BY END USE, AND INDUSTRY STOCKS OF MANGANESE FERROALLOYS AND METAL IN 2009[1]

(Metric tons, gross weight)

End use	Ferromanganese: High carbon	Ferromanganese: Medium and low carbon	Ferromanganese: Total	Silicomanganese	Manganese metal
Steel:					
Carbon	82,800	89,800	173,000	56,400	746
High-strength, low-alloy	13,500	9,620	23,100	5,590	5
Stainless and heat-resisting	6,570	2,190	8,760	14,200	954
Full alloy	14,700	14,000	28,700	13,500	23
Unspecified[2]	939	338	1,280	922	1,900
Total	118,000	116,000	234,000	90,600	3,630
Cast irons	6,550	356	6,910	406	W
Superalloys	W	W	W	--	350
Alloys (excluding alloy steels)	460	497	957	2,750	10,400 [3]
Miscellaneous and unspecified	W	W	W	W	W
Grand total	125,000	117,000	242,000	93,700 [4]	14,300
Total manganese content,[5] 2009	99,100	100,000	200,000	61,900	14,300
Total manganese content,[5] 2008	129,000 [r]	121,000 [r]	250,000 [r]	74,400 [r]	22,200
Total manganese content,[5] 2007	130,000 [r]	92,700 [r]	222,000 [r]	61,000	19,700
Stocks, December 31, 2009, consumers and producers	10,100	21,300	31,400	25,800	682

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Alloys (excluding alloy steels)."-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes electrical and tool steel.

[3] Approximtely 79% of this combined total was for consumption in aluminum alloys.

[4] Internal evaluation indicates that silicomanganese consumption is considerably understated.

[5] Estimated based on typical percentages of manganese content.

TABLE 5

U.S. EXPORTS OF MANGANESE ORE, FERROALLOYS, AND METAL, BY COUNTRY[1]

Country	2008		2009	
	Quantity, gross weight (metric tons)	Value, f.a.s.[2] (thousands)	Quantity, gross weight (metric tons)	Value, f.a.s.[2] (thousands)
Ore and concentrates with 20% or more manganese:[3]				
Canada	1,630	$565	13,900	$923
China	45,300	7,290	--	--
Germany	882	1,800	668	1,750
Korea, Republic of	361	631	527	893
Other (14 countries)	142 r	435 r	184	256
Total	48,300	10,700	15,300	3,830
Ferromanganese, all grades:[4]				
Canada	15,100	11,900	10,900	11,600
Japan	6	4	1,000	1,400
Malaysia	47	48	1,080	1,160
Mexico	4,580	3,390	6,890	8,220
Netherlands	796	734	2,260	2,620
Spain	1,640	176	--	--
Other (16 countries)	1,270 r	4,330 r	1,990	2,880
Total	23,400	20,600	24,200	27,900
Silicomanganese:[4]				
Canada	901	837 r	5,410	5,580
Italy	203	285	2,540	2,010
Mexico	2,650	4,250	7,050	6,510
Netherlands	429	603	1,490	1,340
Spain	1,640	1,650	--	--
Other (10 countries)	1,320 r	1,400 r	2,290	2,040
Total	7,140	9,020	18,800	17,500
Metal, including alloys and waste and scrap:[3]				
Belgium	613	1,740	50	227
China	684	1,520	936	2,310
Hong Kong	522	1,450	820	2,340
Japan	1,120	2,460	462	1,010
Other (27 countries)	1,640 r	4,420 r	1,200	3,140
Total	4,580	11,600	3,470	9,040
Manganese dioxide:[4]				
Belgium	2,170	5,550 r	1,930	4,870
Canada	5,320	4,010	4,090	3,900
Mexico	808	770	341	432
Other (45 countries)	2,710 r	4,260 r	2,060	4,220
Total	11,000	14,600	8,420	13,400

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship.

[3] Countries listed imported more than 300 metric tons from the United States based on the 2-year average.

[4] Countries listed imported more than 500 metric tons from the United States based on the 2-year average.

Source: U.S. Census Bureau.

TABLE 6

U.S. IMPORTS FOR CONSUMPTION OF MANGANESE ORE, FERROALLOYS, METAL, AND SELECTED CHEMICALS, BY COUNTRY[1]

Country	2008			2009		
	Quantity		Value, customs (thousands)	Quantity		Value, customs (thousands)
	Gross weight (metric tons)	Mn content (metric tons)		Gross weight (metric tons)	Mn content (metric tons)	
Ore and concentrates with 20% or more manganese:[2]						
All grades:						
Australia	103,000	51,900	$25,500	35,700	15,400	$12,300
Belgium	--	--	--	1,180	609	136
Brazil	68,300	34,400	19,300	2,960	1,540	929
China	862	516	436	4,170	2,150	617
Gabon	356,000	181,000	85,200	186,000	96,500	65,000
Ghana	12,500	6,230	5,580	37,500	37,100	3,400
India	4	1	8	--	--	--
Mexico	--	--	--	1,490	671	303
Morocco	--	--	--	16	9	11
South Africa	30,800	14,600	18,400	--	--	--
Total	571,000	289,000	154,000	269,000	154,000	82,600
More than 20% but less than 47% manganese:[2]						
Australia	--	--	--	25,600	10,500	10,200
Brazil	4,950	1,540	1,100	--	--	--
Gabon	122,000	57,400	20,400	--	--	--
India	4	1	8	--	--	--
Mexico	--	--	--	1,490	671	303
Total	127,000	58,900	21,500	27,100	11,100	10,500
47% or more manganese:[2]						
Australia	103,000	51,900	25,500	10,100	4,970	2,070
Belgium	--	--	--	1,180	609	136
Brazil	63,300	32,800	18,200	2,960	1,540	929
China	862	516	436	4,170	2,150	617
Gabon	233,000	124,000	64,800	186,000	96,500	65,000
Ghana	12,500	6,230	5,580	37,500	37,100	3,400
Morocco	--	--	--	16	9	11
South Africa	30,800	14,600	18,400	--	--	--
Total	443,000	230,000	133,000	242,000	143,000	72,100
Ferromanganese:[3]						
All grades:						
Australia	1,530	1,170	3,870 [r]	11,000	8,460	11,600
China	111,000	88,500	318,000	10,100	9,160	24,600
India	20,000	14,900	51,000	5,910	4,510	5,930
Korea, Republic of	31,200	24,200	87,100	8,790	7,120	15,700
Mexico	23,600	19,000	49,900	7,750	6,110	13,300
Norway	6,000	4,900	19,100	10,100	8,250	16,300
South Africa	197,000	153,000	451,000	90,200	69,900	118,000
Ukraine	26,200	20,600	68,000 [r]	4,290	3,360	3,670
Other (18 countries)	31,400 [r]	24,700 [r]	86,300 [r]	4,930	3,830	5,810
Total	448,000	351,000	1,130,000	153,000	121,000	215,000

See footnotes at end of table.

TABLE 6—Continued

U.S. IMPORTS FOR CONSUMPTION OF MANGANESE ORE, FERROALLOYS, METAL, AND SELECTED CHEMICALS, BY COUNTRY[1]

Country	2008 Quantity Gross weight (metric tons)	2008 Quantity Mn content (metric tons)	2008 Value, customs (thousands)	2009 Quantity Gross weight (metric tons)	2009 Quantity Mn content (metric tons)	2009 Value, customs (thousands)
1% or less carbon:						
China	33,500	28,100	$111,000	8,580	7,940	$21,900
Korea, Republic of	2,000	1,610	6,940	3,460	2,810	5,370
Mexico	10,900	8,840	26,000	4,340	3,450	8,090
Norway	3,830	3,150	14,200	2,660	2,160	4,710
South Africa	--	--	--	1,020	827	2,560
Other (4 countries)	763	603	2,600	27	21	58
Total	51,000	42,300	160,000	20,100	17,200	42,700
More than 1% to 2% or less carbon:						
China	39,600	31,400	120,000	740	600	1,610
Korea, Republic of	7,600	6,140	25,400	4,630	3,770	9,460
Mexico	12,600	10,100	23,800	1,520	1,210	3,080
Norway	1,170	962	3,420	7,410	6,030	11,400
South Africa	33,300	26,800	82,100	12,300	9,740	26,800
Other (4 countries)	7,210 r	5,910 r	21,100 r	39	31	198
Total	102,000	81,400	276,000	26,600	21,400	52,600
More than 2% but not more than 4% carbon:						
China	633	498	275	--	--	--
Norway	--	--	--	16	13	25
South Africa	54	44	122	216	179	500
Other (3 countries)	3,270 r	2,800 r	10,800 r	405	304	460
Total	3,960	3,340	11,200	637	496	986
More than 4% carbon:						
Australia	1,530	1,170	3,870	11,000	8,460	11,600
China	37,400	28,500	87,100	816	614	1,140
India	20,000	14,900	51,000	5,910	4,510	5,930
Korea, Republic of	21,600	16,400	54,800	701	546	869
Mexico	43	34	147	1,900	1,450	2,130
Norway	1,000	786	1,530	57	46	92
South Africa	164,000	126,000	369,000	76,700	59,100	88,600
Ukraine	24,700	19,300	62,700	4,290	3,360	3,670
Other (12 countries)	21,700 r	16,700 r	57,100 r	4,460	3,480	5,100
Total	292,000	224,000	687,000	106,000	81,600	119,000
Silicomanganese:[3]						
Australia	36,500	23,900	68,800	18,400	12,200	17,200
Georgia	59,800	44,900	116,000	20,300	13,500	15,600
Korea, Republic of	3,820	2,390	7,540	7,090	4,620	6,380
Macedonia	12,900	8,470	27,500	--	--	--
Mexico	16,400	10,800	21,900	1,600	1,050	1,660
Norway	72,500	45,400	136,000	15,200	9,460	22,300
Saudi Arabia	5,150	3,430	10,700	8,760	3,510	7,540
South Africa	153,000	102,000	284,000	55,400	36,800	60,500
Other (8 countries)	5,140 r	3,520 r	10,000 r	3,600	2,320	4,040
Total	365,000	245,000	682,000	130,000	83,500	135,000

See footnotes at end of table.

TABLE 6—Continued

U.S. IMPORTS FOR CONSUMPTION OF MANGANESE ORE, FERROALLOYS, METAL, AND SELECTED CHEMICALS, BY COUNTRY[1]

	2008			2009		
Country	Quantity Gross weight (metric tons)	Quantity Mn content (metric tons)	Value, customs (thousands)	Quantity Gross weight (metric tons)	Quantity Mn content (metric tons)	Value, customs (thousands)
Metal:[2]						
Unwrought:[4]						
China	21,700	XX	$75,000	15,500	XX	$38,100
Germany	1,420	XX	8,220	555	XX	1,660
South Africa	5,570	XX	23,500	4,980	XX	14,100
Other (10 countries)	1,610 r	XX	3,950 r	459	XX	1,150
Total	30,300	XX	111,000	21,500	XX	55,000
Other manganese, wrought:						
China	649	XX	2,320	263	XX	710
Mexico	426	XX	2,530	299	XX	1,530
Other (4 countries)	9	XX	52	52	XX	208
Total	1,080	XX	4,900	614	XX	2,450
Waste and scrap:						
Canada	312	XX	81	701	XX	239
Other (4 countries)	--	XX	--	185	XX	131
Total	312	XX	81	886	XX	370
Manganese dioxide:[2]						
Australia	4,380	XX	6,230	--	XX	--
Japan	4,730	XX	8,620	4,570	XX	11,400
Mexico	3,000	XX	1,420	10	XX	16
South Africa	9,500	XX	19,100	12,200	XX	29,200
Other (11 countries)	1,310 r	XX	2,250 r	723	XX	1,300
Total	22,900	XX	37,600	17,500	XX	42,000
Potassium permanganate:[2]						
Czech Republic	395	XX	1,100	565	XX	1,870
India	305	XX	858	560	XX	1,870
Other (1 country)	14	XX	37	18	XX	62
Total	714	XX	1,990	1,140	XX	3,800

r Revised. XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Countries listed exported more than 300 metric tons (gross weight) to the United States based on the 2-year average.

[3] Countries listed exported more than 5,000 metric tons (gross weight) total ferromanganese to the United States based on the 2-year average.

[4] Imports of unwrought metal include flake, powder, and other.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 7
MANGANESE ORE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	Mn content, percentage[e, 4]	2005	2006	2007	2008	2009
Australia:[5]						
Gross weight		3,136	4,556	5,289	4,812 [r]	4,451
Mn content	37–53	1,500	2,192	2,540	2,320	2,140
Brazil:[6]						
Gross weight		3,200	3,390 [r]	1,570 [r]	3,160 [r]	2,200 [p]
Mn content	33–51[r]	1,370	1,120 [r]	520 [r]	1,040 [r]	730 [p]
China:[e, 7, 8]						
Gross weight		7,500	8,000	10,000	11,000	12,000
Mn content	20–30	1,500	1,600	2,000	2,200	2,400
Gabon:[9]						
Gross weight		2,859	3,000	3,300	3,250 [r]	2,000
Mn content	45–53	1,342 [r]	1,393 [r]	1,532 [r]	1,441 [r]	881
Ghana:						
Gross weight		1,715	1,659	1,173 [r]	1,261 [r]	1,007
Mn content[e]	32–34	600	580	410	440 [r]	351
India:[10]						
Gross weight		2,386	2,084	2,300	2,400	2,500
Mn content	10–54	927	844	900	960	980
Kazakhstan, crude ore:						
Gross weight		2,208	2,531	2,482	2,485	2,467
Mn content[e]	20–30	540	550	600	600	595
Mexico:[11]						
Gross weight		369	346	423	472 [e]	470 [e]
Mn content	36–37	133	124	152	170	169 [e]
South Africa:[9]						
Gross weight		4,612	5,213	5,996	6,807	4,576
Mn content	30–48+	2,100	2,300	2,600	2,900	1,900 [e]
Ukraine:						
Gross weight		2,260	1,606	1,720	1,447	932
Mn content[e]	30–35	770	546	580	490	375
Other:[e, 12]						
Gross weight		745	772	843 [r]	1,000 [r]	965
Mn content	XX	231	227	254 [r]	312 [r]	299
Total:						
Gross weight		31,000	33,200 [r]	35,100 [r]	38,100 [r]	33,600
Mn content	XX	11,000	11,500 [r]	12,100 [r]	12,900 [r]	10,800

[e] Estimated. [p] Preliminary. [r] Revised. XX Not applicable.

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[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 2, 2010. Data pertain to concentrates or comparable shipping product, except that in a few instances the best data available appear to be for crude ore, possibly after some upgrading.

[3] In addition to the countries listed, Cuba, Panama, Philippines, and Sudan may have produced manganese ore and (or) manganiferous ore, but available information is inadequate to make reliable estimates of output levels.

[4] May be average content of each year's production rather than for content of typical products.

[5] Metallurgical ore.

[6] Production of beneficiated ore as reported in Mineral Summary, Brasilia, Brazil. Average content 43% Mn. Contains imports from China and South Africa.

[7] Includes manganiferous ore.

[8] The International Manganese Institute estimated Chinese manganese ore production, in gross weight and Mn content, respectively, in metric tons, as follows: 2005—12,000,000 and 2,400,000; 2006—11,000,000 and 2,200,000; 2007—14,000,000 and 2,800,000; 2008—19,000,000 and 3,400,000; and 2009—15,000,000 and 2,700,000.

TABLE 7—Continued
MANGANESE ORE: WORLD PRODUCTION, BY COUNTRY[1, 2]

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[9] Calculated metal content includes allowance for assumed moisture content. Includes ore and sinter.

[10] Reported on a fiscal year-basis. Much of India's production grades below 35% Mn; content averaged 38.3% Mn for fiscal years 2005–06 through 2009–10.

[11] Mostly oxide nodules; may include smaller quantities of direct-shipping carbonate and oxide ores for metallurgical and battery operations.

[12] Category represents the combined totals of Bosnia and Herzegovina, Bulgaria, Burkina Faso, Burma, Chile, Colombia, Cote d'Ivoire, Egypt, Georgia, Hungary, Indonesia, Iran, Italy (from wastes), Morocco, Namibia, Romania, Russia (crude ore), Thailand, Turkey, and Zambia.

TABLE 8
FERROMANGANESE AND SILICOMANGANESE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country	2005	2006	2007	2008	2009[e]
Argentina, electric furnace, silicomanganese[e]	13,290 [r]	9,268 [r]	8,917 [r]	9,172 [r]	6,644 [3]
Australia, electric furnace:[e]					
Ferromanganese	120,000	125,000	115,000 [r]	147,000 [r]	87,000
Silicomanganese	120,000 [r]	120,000 [r]	110,000 [r]	125,000 [r]	74,000
Total	240,000 [r]	245,000 [r]	225,000 [r]	272,000 [r]	161,000
Brazil, electric furnace:					
Ferromanganese	182,400	280,770	205,000 [r, e]	190,000 [r, e]	66,000
Silicomanganese	297,600	292,230	214,000 [r, e]	198,000 [r, e]	69,000
Total	480,000	573,000	419,000 [r, e]	388,000 [r, e]	135,000
China:[e]					
Blast furnace, ferromanganese	500,000	600,000	600,000	600,000	500,000
Electric furnace:					
Ferromanganese	1,150,000	1,400,000	1,930,000	2,100,000	2,300,000
Silicomanganese	3,000,000	3,600,000	4,340,000	5,000,000 [r]	5,200,000
Total	4,150,000	5,000,000	6,270,000	7,100,000	7,500,000
Total, blast and electric furnaces	4,650,000	5,600,000	6,870,000	7,700,000 [r]	8,000,000
Egypt, electric furnace, ferromanganese[e]	30,000	30,000	30,000	30,000	30,000
France, electric furnace:[e]					
Ferromanganese	113,000 [r]	137,000 [r]	144,000 [r]	46,600 [r]	46,000
Silicomanganese[4]	52,300	63,300	65,400 [r]	60,200 [r]	54,100
Total	165,000 [r]	200,000 [r]	209,000 [r]	107,000 [r]	100,000
Georgia, electric furnace:[e]					
Ferromanganese	13,945 [3]	5,130 [3]	5,000	5,000	4,500
Silicomanganese	109,414 [3]	116,945 [3]	120,000	120,000	105,000
Total	123,359 [3]	122,075 [3]	125,000	125,000	110,000
India, electric furnace:[5]					
Ferromanganese:	273,057 [r]	296,726 [r]	391,210 [r]	384,577 [r]	389,465 [3]
Silicomanganese	596,372 [r]	782,962 [r]	911,402 [r]	891,458 [r]	1,099,838 [3]
Total	869,429 [r]	1,079,688 [r]	1,302,612 [r]	1,276,035 [r]	1,489,303 [3]
Indonesia, electric furnace:[e]					
Ferromanganese	12,000	12,000	12,000	12,000	12,000
Silicomanganese	4,000	5,000	6,000	7,000	7,000
Total	16,000	17,000	18,000	19,000	19,000
Iran, electric furnace, ferromanganese[6]	NA	NA	NA	NA	NA
Italy, electric furnace:[e]					
Ferromanganese	9,000 [r]	4,500 [r]	4,800 [r]	8,500 [r]	5,500
Silicomanganese	21,500 [r]	33,500 [r]	37,000 [r]	25,500 [r]	17,000
Total	30,500 [r]	38,000 [r]	41,800 [r]	34,000 [r]	22,500
Japan, electric furnace:					
Ferromanganese	448,616	406,162	420,151	431,181 [r]	361,375 [3]
Silicomanganese	94,725	59,424	52,901	58,884 [r]	49,205 [3]
Total	543,341	465,586	473,052	490,065 [r]	410,580 [3]

See footnotes at end of table.

TABLE 8—Continued

FERROMANGANESE AND SILICOMANGANESE: WORLD PRODUCTION, BY COUNTRY[1,2]

(Metric tons, gross weight)

Country	2005	2006	2007	2008	2009[e]
Kazakhstan, electric furnace:					
Ferromanganese[e]	2,100	2,100	2,100	2,100	1,900
Silicomanganese	170,214	220,000	188,445	179,939	160,000
Total	172,314	222,100	190,545	182,039	162,000
Korea, Republic of, electric furnace:					
Ferromanganese	124,434	169,202	209,321	251,125	250,000
Silicomanganese	74,193	94,119	105,607	76,184	80,000
Total	198,627	263,321	314,928	327,309	330,000
Macedonia, electric furnace:					
Ferromanganese	--	--	--	12,623	--
Silicomanganese	--	--	70,472	54,931	--
Total	--	--	70,472	67,554	--
Mexico, electric furnace:[7]					
Ferromanganese	89,642	62,485	74,578	97,366	42,492 [3]
Silicomanganese	104,780	97,457	109,286	114,320	85,065 [3]
Total	194,422	159,942	183,864	211,686	127,557 [3]
Norway, electric furnace:[e]					
Ferromanganese	250,000	245,000	245,000	309,000 [r]	205,000
Silicomanganese	230,000	230,000	225,000	252,000 [r]	200,000
Total	480,000	475,000	470,000	561,000 [r]	405,000
Poland:					
Blast furnace, ferromanganese	7,800	4,100	2,100 [r]	4,100 [r, e]	4,100
Electric furnace, silicomanganese	10,242	3,310	15,600 [r]	24,000 [r, e]	24,000
Total	18,042	7,410	17,700 [r]	28,100 [r, e]	28,100
Romania, electric furnace:					
Ferromanganese	18,625	3,329	--	--	--
Silicomanganese	100,957	53,085	26,868	10,000	--
Total	119,582	56,414	26,868	10,000	--
Russia:[e]					
Blast furnace, ferromanganese	110,000	130,000	120,000	110,000	100,000
Electric furnace, silicomanganese	48,000	40,000	40,000	40,000	35,000
Total	158,000	170,000	160,000	150,000	135,000
Slovakia, electric furnace:					
Ferromanganese	43,458	59,391	74,065	61,194	60,000
Silicomanganese	47,843	59,128	71,587	59,940	60,000
Total	91,301	118,519	145,652	121,134	120,000
South Africa, electric furnace:					
Ferromanganese	570,574	656,235	698,654	503,000 [r]	260,000
Silicomanganese[e]	231,000	247,000	302,000	233,000 [r]	110,000
Total	801,574	903,235	1,000,654	736,000 [r]	370,000
Spain, electric furnace:[e]					
Ferromanganese	10,000	10,000	10,000	10,000	10,000
Silicomanganese	100,000	100,000	100,000	30,000 [r]	30,000
Total	110,000	110,000	110,000	40,000 [r]	40,000
Ukraine:					
Blast furnace, ferromanganese	79,000 [r]	30,000 [r]	26,700 [r]	16,000 [r]	--
Electric furnace:					
Ferromanganese	359,000	373,000	368,000	361,501	129,400 [3]
Silicomanganese	1,040,000	1,168,000	1,281,000	958,667	741,900 [3]
Total	1,399,000	1,541,000	1,649,000	1,320,168	871,300 [3]
Total, blast and electric furnaces	1,478,000 [r]	1,571,000 [r]	1,675,700 [r]	1,336,168 [r]	871,300 [3]
United States, electric furnace, ferromanganese[8]	W	W	W	W	W

See footnotes at end of table.

TABLE 8—Continued
FERROMANGANESE AND SILICOMANGANESE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country	2005	2006	2007	2008	2009[e]
Venezuela, electric furnace:[e]					
Ferromanganese	15,000	15,000	15,000	15,000	15,000
Silicomanganese	35,000	35,000	35,000	35,000	35,000
Total	50,000	50,000	50,000	50,000	50,000
Grand total	11,000,000 [r]	12,500,000 [r]	14,100,000 [r]	14,300,000 [r]	13,100,000
Of which:					
Blast furnace, ferromanganese	697,000 [r]	764,000 [r]	749,000 [r]	730,000 [r]	604,000
Electric furnace, excluding United States:					
Ferromanganese	3,830,000 [r]	4,290,000 [r]	4,950,000 [r]	4,980,000 [r]	4,280,000
Silicomanganese[9]	6,500,000 [r]	7,430,000 [r]	8,440,000 [r]	8,560,000 [r]	8,240,000
Total	10,300,000	11,700,000	13,400,000	13,500,000	12,500,000

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data; not included in "Grand total." NA Not available. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through December 31, 2010.

[3] Reported figure.

[4] Includes silicospiegeleisen, if any.

[5] Reported on a fiscal year basis, which is from April 1 to March 31.

[6] In addition to ferromanganese, Iran is thought to have produced silicomanganese, but production information is inadequate for the formulation of estimates of output levels.

[7] Salable products from Cía Minera Autlán S.A. de C.V.

[8] U.S. output of ferromanganese includes silicomanganese.

[9] Includes silicospiegeleisen, if any, for France.

TABLE 9

MANGANESE MATERIALS: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY YEAREND 2013[1, 2, 3]

(Metric tons, gross weight, unless otherwise specified)

Projected year of first production	Country	Project and company	Project type	Incremental annual production capacity	Total annual production capacity	Manganese product[4]
2009	Australia	Bootu Creek Manganese Mine OM Holdings Ltd.[r]	mine expansion	150,000	850,000	Mn ore.
2009	Do.	Groote Eylandt Mining Company Pty. Ltd. BHP Billiton Limited (60%) and Anglo American Corporation (40%)	do.	700,000	4,200,000[r]	Do.
2009	China	Anhui EMM Plant Anhui Chizhou Jinshan Mining Co., Ltd. (50%)[e] and Hubei Jiayu Gaoqiang Manganese Co., Ltd. (50%)[e]	new EMM plant	NA	30,000	EMM.
2009	Do.	Erdos EJM Manganese Alloys Co. ERDOS Group (51%), JFE Steel Corporation (24.5%), and Mitsui & Co. (24.5%)	ferroalloys plant expansion	300,000 NA	450,000 186,000	SiMn. FeMn.
2009	Do.	Guangxi Eramet-Comilog EMD Plant Guangxi Eramet-Comilog Chemicals Co., Ltd.	EMD plant expansion	10,000	20,000	EMD.
2009	Do.	Henan Qi County Qianyuan Plant Henan Qi County Qianyuan Furnace Charge Co., Ltd.	ferroalloys plant expansion	50,000	170,000	SiMn.
2009	Do.	Sinosteel Jilin Ferroalloy Plant Sinosteel Jilin Ferroalloy Co., Ltd.	do.	45,000	205,000	Do.
2009	Do.	Windsor Manganese Ltd. Singapore Windsor Holdings	new ferroalloys plant	NA	100,000	Do.
2009	Gabon	Moanda Mine Compagnie Miniere de l'Ogooue (Comilog) S.A.	mine expansion	200,000	3,700,000	Mn ore.
2009	India	Aryan Mining Trade Company Stemcor Group	do.	60,000	120,000	Do.
2009	Do.	Orissa Manganese and Minerals Pvt. Ltd. Adhunik Metaliks Ltd.	do.	NA	300,000	Do.
2009	Russia	Selezen Manganese Mine SGMK Shalymskaya Mining Company	new mine	NA	NA	Do.
2009	Do.	Siberian Mining and Metallurgical Company (SGMK) Ferro Alloys Plant SGMK	new ferroalloys plant	NA	45,000	Mn alloys.
2010	Australia	Ant Hill and Sunday Hill Mesa Minerals Limited[r, 5]	do.	NA	300,000	Do.
2010	Do.	Bootu Creek Manganese Mine OM Holdings Ltd.[r]	mine expansion	150,000	1,000,000	Do.
2010	Do.	Nicholas Downs (formerly Balfour Downs) Manganese Project Mineral Resources Limited (50%) and Hancock Prospecting Pty. Ltd. (50%)[r]	do.	NA	350,000[r]	Do.
2010	Do.	Peak Hill District Manganese Project Mineral Resources Limited	do.	85,000	220,000	Do.
2010[e]	China	CITIC Dameng Tiandong Plant CITIC Dameng Tiandong New Materials Co., Ltd.	new EMM plant	NA	30,000	EMM.

See footnotes at end of table.

TABLE 9—Continued

MANGANESE MATERIALS: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY YEAREND 2013[1, 2, 3]

(Metric tons, gross weight, unless otherwise specified)

Projected year of first production	Country	Project and company	Project type	Incremental annual production capacity	Total annual production capacity	Manganese product[4]
2010	China	Wuhai Mengjin Smelting Wuhai Mengjin Smelting Co. Ltd.	ferroalloys plant expansion	120,000	170,000	SiMn.
2010	Gabon	Manganese Project, Bembélé Mountains Compagnie Industrielle et Commerciale des Mines de Huazhou (CICMH)	new mine	NA	500,000	Mn ore.
2010	India	Bhilai Ferro-Alloys Plant Manganese Ore (India) Limited (MOIL) (50%) and Steel Authority of India Limited (50%)	new ferroalloys plant	NA	100,000 [r]	Mn alloys.
2010	Do.	Rohit Ferro Tech Haidia Plant Rohit Ferro Tech Ltd.	do.	NA	600,000 [r]	FeMn, SiMn.
2010	South Africa	Kalahari Manganese Project United Manganese of Kalahari	mine expansion	750,000	1,000,000	Mn ore.
2010[e]	Zambia	Otjosondu Manganese Mine Purity Manganese (pty.) Ltd.	do.	480,000	600,000	Do.
2011[e]	Do.	Taurian Manganese Ferroalloys Plant Dharni Sampda Private Limited Group (formerly Taurian Resources Private Limited)	new ferroalloys plant	NA	45,000	Mn alloys.
2011	Australia	Peak Hill District Manganese Project Mineral Resources Limited	mine expansion	60,000	280,000	Mn ore.
2011	China	Eramet New Guilin Project Eramet S.A.	new ferroalloys plant	NA	100,000 60,000	HC FeMn, SiMn. MC FeMn, LC FeMn.
2011	Do.	Guangxi Manganese Plant Guangxi Zhaohong Manganese Industry Co., Ltd.	new EMM plant	NA	24,000	EMM.
2011[e]	Cote d'Ivoire	Lauzoua Mine Societe pour le Developpement Minier en Cote d'Ivoire (51%), China National Geological & Mining Corporation (39%), and the State of Cote d'Ivoire (10%)	new mine	NA	150,000	Mn ore.
2011[e]	India	Chandrapur Plant Maharashtra Elektrosmelt Ltd.	ferroalloys plant expansion	60,000	180,000	FeMn, SiMn.
2011	Do.	Maithan Vizag Ferro-Alloys Plant Maithan Alloys Limited	new ferroalloys plant	NA	120,000	Mn alloys.
2011[r]	Do.	Patmunda Manganese Mine[r, 6] Orissa Manganese and Minerals Pvt. Ltd.	mine expansion	210,000 [r, e]	360,000 [r]	Mn ore.
2011	Do.	Rohit Ferro Tech Orissa Plant Rohit Ferro Tech Ltd.	ferroalloys plant expansion	50,000	160,000	HC FeCr, HC FeMn, SiMn.
2011	Do.	Rungta Manganese Mine Rungta Mines Ltd.	mine expansion	75,000	250,000	Mn ore.
2011	Do.	10 mines[7] MOIL	do.	600,000	2,000,000	Do.
2011	Korea, Republic of	Gwangyang Ferromanganese Plant POS-HiMetal	new ferroalloys plant	NA	75,000	FeMn.

See footnotes at end of table.

TABLE 9—Continued

MANGANESE MATERIALS: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY YEAREND 2013[1, 2, 3]

(Metric tons, gross weight, unless otherwise specified)

Projected year of first production	Country	Project and company	Project type	Incremental annual production capacity	Total annual production capacity	Manganese product[4]
2011	Russia	Usink Manganese Mine ZAO ChEK.SU-Vk	new mine	NA	300,000 e	Do.
2011 r	South Africa	Kalagadi Manganese Project Kalagadi Manganese (50%) and ArcelorMittal (50%)	new mine-beneficiation-sinter complex[8] (Northern Cape Province) and ferroalloys plant (Coega, Eastern Cape Province)	NA NA	3,000,000 320,000	Mn ore. FeMn.
2012	Cameroon	Nkamouna Cobalt-Nickel-Manganese Project Geovic Mining Corporation	new mine	NA	45,000	Mn ore.
2012 e	China	Sinosteel Jilin Ferroalloy Plant Sinosteel Jilin Ferroalloy Co., Ltd.	new ferroalloys plant	NA	100,000	MC FeMn, LC FeMn.
2012 r	Gabon	Moanda Mine Comilog S.A.	mine expansion	300,000	4,000,000	Mn ore.
2012 r	India	Bobbili Ferro-Alloys Plant MOIL (50%), Rashtriya Ispat Nigam Limited (50%)	new ferroalloys plant	NA	45,000	SiMn.
2012 r	Russia	Krasnoyarsk Ferroalloys Plant ZAO ChEK.SU-Vk and Krasnoyarsk Territory Administration Council	do.	NA	62,500 r, 9	Mn alloys.
2012	South Africa	Kalahari Manganese Project United Manganese of Kalahari	mine expansion	500,000	1,500,000	Mn ore.
2012	Do.	Wessels Mine BHP Billiton Limited	do.	500,000 r	1,500,000 r	Do.
2013 e	China	Sinosteel Jilin Ferroalloy Plant Sinosteel Jilin Ferroalloy Co., Ltd.	ferroalloys plant expansion	600,000 e	1,000,000	FeMn.
2013	Gabon	Moanda Metallurgical Complex Comilog S.A.	new EMM and SiMn plants	NA NA	65,000 20,000	SiMn. EMM.
2013	Russia	Krasnoyarsk Ferroalloys Plant ZAO ChEK.SU-Vk and Krasnoyarsk Territory Administration Council	new ferroalloys plant	62,500 e	125,000 r, 9	Mn alloys.
2013 r	South Africa	Tshipi Kalahari Manganese Project Pallinghurst Co.-Investors (49.9%), OM Holdings Limited (26%), Ntsimbintle Mining (PTY) Ltd. (24.1%)	new mine	NA	2,200,000	Mn ore.

e Estimated. r Revised. Do., do. Ditto. NA Not available.

[1] Estimated data are rounded to no more than three significant digits.

[2] Projects in feasibility or later stages of development in 2009. Actual startup dates may be postponed, owing to economic or other factors. Additional projects might produce manganese materials by 2013, but not enough information was available to include them.

[3] Includes projects having the following minimum tonnage capacities: 45,000 metric tons of manganese alloys or manganese ore; and 10,000 metric tons of electrolytic manganese dioxide or electrolytic manganese metal.

[4] EMD Electrolytic manganese dioxide. EMM Electrolytic manganese metal. FeMn Ferromanganese. HC FeCr High-carbon ferrochromium. HC FeMn High-carbon ferromanganese. LC FeMn Low-carbon ferromanganese. MC FeMn Medium-carbon ferromanganese. Mn Manganese. SiMn Silicomanganese.

[5] In 2010, Mineral Resources Limited acquired 64% controlling ownership in project from Mesa Minerals.

[6] Includes five additional manganese mines situated in the same region of Sundargarth, Orissa.

[7] Manganese Ore (India) Limited (MOIL) operates 10 mines, 6 of which are located in the Nagpur and Bhandara Districts of Maharashtra and 4 in the Balaghat District of Madhya Pradesh. The company has not specified which mines would be affected by the planned capacity expansion.

[8] The Kalagadi Manganese sinter plant will have a capacity of 2.4 million metric tons per year.

TABLE 9—Continued

MANGANESE MATERIALS: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY YEAREND 2013[1, 2, 3]

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[5] The plant's total production capacity will be 250,000 metric tons per year by 2016.

Sources: Company annual reports, presentations, and press releases; unpublished personal communications; and trade publications.

MERCURY

By William E. Brooks

Domestic tables were prepared by Barbara J. McNair, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2009, there were no mines with mercury as a principal product in the United States. The last mine to produce mercury as its principal product, the McDermitt Mine in northern Nevada, closed in 1992. In 2009, mercury was produced as a byproduct of domestic gold-silver processing, mainly in Nevada, and may have been produced as a byproduct of processing other metals. Imported byproduct mercury was processed, and the mercury was resold. Recycled mercury was produced from reclamation of mercury contained in fluorescent lamps and a declining supply of mercury-containing automobile convenience switches, batteries, dental amalgam, electronic waste, medical devices, and thermostats. The chlorine-caustic soda industry was the leading domestic user of mercury for its mercury-cell plants, and some of that mercury is recycled in-plant. Data on domestic byproduct and recycled mercury production were not available.

Since 1927, the common unit for measuring and pricing mercury has been the "flask," which was set to conform to the historical measuring system used at Almaden, Spain (Myers, 1951). One flask of mercury weighs 34.5 kilograms (kg), and 1 metric ton (t) of mercury contains approximately 29 flasks. The flask itself is a screw-top, welded-steel container that is approximately the size of a 2-liter bottle.

Legislation and Government Programs

The Mercury Pollution Reduction Act of 2009 (H.R. 2065) was introduced and referred to the House Committee on Energy and Commerce on April 23. This legislation indicated that the United States should develop policies to reduce mercury use and emissions, mercury releases, and exposure to mercury, particularly for women of childbearing age. The legislation would amend the Toxic Substances Control Act to prohibit the manufacture of chlorine or caustic soda using mercury technology and the export of mercury, mercury compounds, and mixtures containing mercury. The Secretary of Energy would be required to develop a storage system for mercury, mercury compounds, and mixtures containing mercury from chlorine-caustic soda plants. Additionally, the owners of chlorine-caustic soda plants would be required to report to the U.S. Environmental Protection Agency (EPA) and to the State in which the facility was located on mercury content in products, emissions, and waste. The legislation would require the EPA to conduct a mercury inventory covering the closure of chlorine-caustic soda facilities that ceased operations on or after January 1, 2009, and obtain mercury purchase records and other information from each facility so as to determine mercury releases from the facility into the environment (U.S. Congress, 2009).

The EPA proposed a significant new use rule under the Toxic Substances Control Act of 1976 for elemental mercury used in flow meters, natural gas manometers, and pyrometers. This action required manufacturers and importers to notify the EPA at least 90 days before beginning the mercury-related activity. The notification would provide EPA with the opportunity to evaluate the intended use, and if necessary, limit or prohibit the activity (U.S. Environmental Protection Agency, 2009a).

The EPA proposed to reduce mercury emissions from portland cement kilns, which are the fourth-leading source of mercury air emissions in the United States. The proposal set limits on emissions from existing kilns and strengthened mercury-emissions limits on new kilns. When fully implemented in 2013, the EPA estimated that this rule would reduce annual mercury emissions by 81% or 5 t (U.S. Environmental Protection Agency, 2009b).

The Mercury Export Ban Act of 2008 (Public Law 110–414), also known as MEBA, which was signed by the President in October 2008, prohibited sale and transfer of elemental mercury after January 1, 2013, and addressed long-term storage of elemental mercury. However, the MEBA did not ban the export of mercury compounds. Therefore, as required under section 4 of the MEBA, the EPA published and submitted to Congress, a report on mercuric chloride, mercurous chloride or calomel, mercuric oxide, and other mercury compounds that may be used in significant quantities. The report included an analysis of the sources and amounts of each mercury compound imported into or manufactured in the United States annually; applications of the compounds, the amounts used, and estimated amounts for 2010 and beyond; the sources and amounts of each mercury compound exported from the United States annually from 2006 through 2008; the potential for these compounds to be processed into elemental mercury after export from the United States; and other relevant information (U.S. Environmental Protection Agency, 2009c, p. 3).

Many State and municipal wastewater treatment plants worked toward reducing mercury releases in wastewater from dental offices. Therefore, on December 29, 2008, the EPA signed a memorandum of understanding with the American Dental Association and the National Association of Clean Water Agencies to establish and monitor the effectiveness of a voluntary dental amalgam discharge reduction program. The purpose was to have dental offices install and maintain amalgam separators and recycle the amalgam waste. The program will also track the percentage of dental offices that install and used amalgam separators (U.S. Environmental Protection Agency, 2008).

The U.S. Geological Survey (USGS) published a report on mercury in top-predator fish, bed sediment, and water from streams in the United States. Sites were sampled to determine regional and national gradients of mercury source and strength that would influence bioaccumulation of methylmercury. Mercury in fish at 27% of the sampled sites exceeded the EPA human health criterion of 0.3 micrograms per gram (µg/g) weight. These sites were geographically widespread (Scudder and others, 2009, p. 2).

Mercury was widely used in small-scale gold mining in Latin America and it was common to burn the mercury-gold amalgam in the gold shops in order to purify the gold for sale—a practice that has become a source of mercury pollution in the shops and in the nearby communities (Habegger and others, 2008, p. 5).

Owing to increased gold prices, many small-scale gold miners have moved to the Amazon region of Peru, which is the world's fifth leading gold producer, to search for placer gold. This has brought about increased use of mercury in Peru and mercury releases to the environment (Keane, 2009). The EPA continued its efforts to provide its mercury reduction technology to gold shops in Brazil, Peru, and other parts of Latin America and partnered with colleagues from the USGS, the U.S. Embassy, Lima, and Peruvian Government officials in order to work more effectively on this problem. The introduction of mercury emission reduction technology to gold shops in Peru resulted from a USGS in-country study of mercury use in Peru (Brooks and others, 2007, p. 7).

The National Defense Stockpile (NDS) held an inventory of 4,436 t of mercury at several sites in the United States. Mercury sales from the NDS were suspended in 1994 in response to environmental concerns. In 2004, the DLA indicated that the mercury would be consolidated at one site in Nevada (Joseph Johnson, specialist, Defense Logistics Agency, written commun., April 30, 2004). The U.S. Department of Energy has 1,329 t of mercury in storage facilities in Oak Ridge, TN. In 2009, seven States were considered as possible mercury storage sites for the Nation's excess mercury; these were Colorado, Idaho, Missouri, Nevada, South Carolina, Texas, and Washington (Dininny, 2009). Hearings on mercury storage were held in Grand Junction, CO, and Kansas City, MO, with most attendees indicating opposition to mercury storage in or near their communities. The Governor of Idaho indicated that he will oppose the use of the Idaho National Laboratory for mercury storage and the State of Washington wants to make sure that potential mercury storage at its Hanford Site would not interfere with current environmental cleanup owing to earlier treatment and storage of radioactive waste (Cary, 2009).

Production

In 2009, byproduct mercury was produced at several precious metals mines in Nevada and was imported from foreign sources. The mercury was processed and refined for resale (Bethlehem Apparatus Co., Inc., 2009b). Data on the amount of byproduct mercury produced in the United States were not available. Mercury has not been mined as a principal product in the United States since 1992, when the McDermitt Mine in Nevada closed.

Consumption

In 2009, less than 100 metric tons per year of mercury was consumed domestically. Domestic mercury consumption was broadly estimated to be about 50% for chlorine-caustic soda manufacture and 50% for other uses (Brooks and Matos, 2005, p. 3). Compact fluorescent lamps, which contain 3 to 5 milligrams (mg) of mercury, were promoted as alternatives to standard fluorescent lamps (Von Ahn, 2007).

Global human health and environmental concerns about mercury have caused a decline in mercury purchases by the chlorine-caustic soda industry as well as an overall market shift in the chlorine-caustic soda industry from mercury cell technology toward nonmercury chlorine production technology. Since 1995, total annual mercury used by the industry has been reduced by 97%. In 1996, there were 14 operating mercury cell plants and at yearend 2008, 5 mercury cell plants were in operation in the United States, and 1 plant converted to membrane technology in 2009. Therefore, only four mercury-cell facilities were expected to be in operation in the United States by yearend 2009. These include mercury-cell facilities in Georgia, Ohio, Tennessee, and West Virginia (Lydersen, 2009). Mercury use at yearend 2008 was 4 t and mercury purchases were 1.2 t; however, mercury purchases do not equate to mercury use owing to process upgrades and longer piping runs that require more mercury (Chlorine Institute, Inc., The, 2009). As mercury-cell plants close around the world, that mercury, as well as mercury from remediation of the plant facilities and soil, will become available for recycling and sale.

Chlorine-caustic soda industry emissions are a very small portion, approximately 2.5%, of the total mercury emitted in the United States. Mercury releases to the environment from the chlorine-caustic soda industry were approximately 2 t in 2008, which was an 83% reduction in mercury releases since 2001 (Chlorine Institute, Inc., The, 2009).

Owing to the concern over the environmental impact of mercury, a stabilization process has been developed in the United States. This process converts mercury into a high-purity mercury sulfide with the same physical and chemical characteristics of naturally occurring cinnabar. The mercury sulfide is then blended with polymers resulting in a red, 7 millimeter (mm) × 7 mm pellet that is suitable for land disposal. This product is currently acceptable for disposal in landfills in Canada and awaits certification from the EPA for disposal in the United States (Bethlehem Apparatus Co., Inc., 2009a).

Recycling

Mercury was reclaimed from end-of-service automobile convenience switches, dental amalgam, fluorescent lamps, laboratory and medical devices, and thermostats in 2009. The National Vehicle Switch Recovery Program was started in 2006 to stop toxic emissions of mercury when cars are scrapped and then melted to make new steel. From 2006 through 2009, the National Vehicle Mercury Switch Recovery Program was supported by payments to dismantlers from the auto and steel industries. Payments were as much as $4 per switch, and the cumulative amount of mercury kept out of furnaces was 3 t (Schaffer, 2009). These and other mercury-containing materials were treated in multistep high-temperature retorts in which the mercury was first volatilized and then condensed for purification and sale (Brooks and Matos, 2005, p. 1).

Owing to Public Law 110–140 and the ban on incandescent bulbs, compact fluorescent lamps, which contain 3 to 5 mg of mercury, have been added to the list of recyclable products. Lamp manufacturers and recyclers encouraged consumers to return the used lamps for recycling by providing shipping materials or collection programs (National Electrical Manufacturers Association, 2008).

Byproduct mercury from domestic and foreign sources and mercury reclaimed from end-of-service products were processed or "recycled" in the United States and then sold into the international metals market. No data were available on the amount of mercury recycled from these respective sources.

In 2009, the major companies that recycled mercury included AERC.com, Inc., Allentown, PA; Bethlehem Apparatus Co., Inc., Bethlehem, PA; Clean Harbors Environmental Services, Inc., Braintree, MA; D.F. Goldsmith Chemical and Metal Corp., Evanston, IL; Mercury Waste Solutions, Mankato, MN; and Onyx Environmental Services, Lombard, IL. Mercury Recyclers maintains a list of as many as 50 companies whose role was mainly collection of mercury-containing materials that would ultimately be moved on to the larger companies for retorting (Mercury Recyclers, 2009).

In 2009, Thermostat Recycling Corp. (TRC) (Rosslyn, VA) reported that national collection of mercury-containing thermostats increased by 16%, to 580 kg in 2008 from 500 kg in 2007. There were 45 States that participated in the collection program, and a total of 135,604 thermostats were collected, with each containing from 2.5 to 10 grams of mercury (Tibbets, 2009).

Prices

In 2009, domestic mercury prices ranged from $600 to $700 per flask from January to early August, then ranged from $500 to $600 per flask for the remainder of the year (Platts Metals Week, 2009). The price of mercury is a product of a diminished supply of mercury from recycled mercury-containing products, fluctuations in imports of mercury, and fluctuations in domestic byproduct production of mercury. Increased gold prices in 2009, to as high as $1,215 per troy ounce, have resulted in growth in the global demand for mercury for small-scale gold mining. For comparison, in 2000–03, the average price of gold was $310 per troy ounce and the average price of mercury was $140 per flask.

Foreign Trade

In 2009, mercury imports totaled 206 t and exports totaled 753 t. Peru (92 t) and Chile (88 t) were the leading sources of imported mercury, produced as a byproduct of large-scale precious metals mining. The Netherlands (414 t), Peru (110 t), and India (107 t) were the principal destinations for mercury exported in 2009. Mercury exported to the Netherlands may be held in warehouses for sale and shipment to global destinations (Fialka, 2006). Mercury imports in 2009 were 33% more than those in 2008. Imports of mercury may vary from year to year, possibly owing to stockpiling of byproduct mercury produced at foreign gold smelters before shipment or upon closure of chlorine-caustic soda plants.

In 2009, a total of 14 t of amalgam, which contains some amount of mercury but is not otherwise chemically defined, was imported into the United States. Principal source countries were Germany (4 t), Mexico (3 t), and the United Kingdom (2 t). A total of 154 t of amalgam was exported from the United States. Principal destination countries were Hong Kong (20 t), Mexico (18 t), Japan (16 t), and China (15 t). Some of this may have been mercury-containing chlorine-caustic soda waste.

World Review

In 2009, world mercury mine production was estimated to be 1,920 t. China was the leading producer (1,400 t) followed by Kyrgyzstan (250 t). Peru produced 140 t of mercury as a byproduct of precious metals processing. Production estimates have a high degree of uncertainty because most companies and countries do not report primary (including byproduct) or secondary production data owing to environmental and health concerns.

European Union.—Euro Chlor (Brussels, Belgium), representing the European chlorine-caustic soda industry, welcomed the voluntary agreement by chlorine producers to ensure safe disposal of the thousands of tons of mercury that come from decommissioned chlorine-caustic soda plants. On December 4, Euro Chlor met its first deadline in the European Union regulation on export ban and storage, which required that quantities of metallic mercury on chlorine-caustic soda sites be reported. Euro Chlor volunteered to gather the data from member companies in order to facilitate the report, and the total amount of mercury on site was 8,480 t (Euro Chlor, 2009). Euro Chlor and its member companies had previously signed the Euro Chlor voluntary agreement on safe storage of decommissioned mercury once the European export ban on mercury becomes effective in 2011 (Metal-Pages, 2008a).

China.—Mercury has been mined in the Wanshan District, Guizhou Province, for 4,000 years, and cinnabar was used in ancient China as a pigment and as a medicine to promote longevity (Liu, 2005). Guizhou is known as the "mercury capital" of China and more than 60% of China's mercury occurrences were discovered in this Province. China is the world's leading producer of mercury and 1,400 t (estimated) was produced in 2009.

In China, mercury emissions come from artisanal cinnabar retorting and zinc smelting in Guizhou, which is also one of the largest coal-producing provinces in China. Mercury content of the coal is significantly elevated when compared with the average mercury content of Chinese coal (Feng and others, 2005; Feng, 2006). The 2009 International Conference on Mercury as a Global Pollutant was sponsored by the Chinese Academy of Sciences, the Chinese Society of Mineralogy, Petrology, and Geochemistry, and the State Key Laboratory of Environmental Geochemistry. Papers were presented on health impacts of mercury, pollution control, mercury methylation, environmental monitoring, and other topics (International Conference on Mercury as a Global Pollutant, 2009). Mercury has also been produced as a byproduct of gold mining and from mercury mines in the Upper Yangtze, Kuniun-Qinling, Sanjiang, and South China metallogenic regions (Lixian and Ruolan, 1992, p. 147).

Japan.—The Nomura Kohsan Co. Ltd. (Tokyo, Japan), which began as owners of the Itomuka Mine (mercury) that closed in 1974 in Hokkaido Prefecture, was the only company in Japan with treatment facilities for mercury-contaminated waste, and including mercury-containing batteries, fluorescent lamps, switches, and thermometers. Approximately 15 t was recovered from end-of-service mercury-containing devices and approximately 75 t was recovered from nonferrous metals refineries in 2009 (Nomura Kohsan Co., Ltd., 2009). More than 78% of solid waste in Japan is incinerated; therefore, control of mercury emissions from the incinerators is important. Activated carbon technology has been shown to reduce mercury emissions by 30% (Takaoka and others, 2002).

Kyrgyzstan.—The Haidarkan mercury mine and smelter in the Batken District, southern Kyrgyzstan, was the only known mercury mine in the world which continued to sells its product to the global market, and in 2008, the mine produced 300 t of mercury. The Haidarkan Mine complex remained open because of the demand for mercury, the lack of international controls, and the fact that the mine is a source of income for the region (Kirby, 2009, p. 10). The Government planned to sell 99.98% of its shares at auction. The Haidarkan plant is the largest producer of mercury in central Asia; however, since the beginning of

2009, output at Haidarkan has declined owing to depletion of the ore, lower ore grade, difficult working conditions, and a shortage of skilled workers (Metal-Pages, 2009).

The global reduction of the mercury supply has been identified as a priority by the United Nations Environment Programme (UNEP) Governing Council, which considers primary mercury mining as an important activity to be studied in order to reduce global emissions of mercury to the environment. Therefore, UNEP carried out a multiagency assessment funded by the Government of Switzerland and UNEP. The report indicated that Haidarkan continued to operate despite technical difficulties and debate about its environmental impact. Haidarkan management planned to increase mining operations and mercury output as well as widen the range of products to include antimony and cement. Waste material from mercury production would be used in cement production, which could result in increased mercury released to the environment owing to high mercury concentration (approximately 200 parts per million) in the slag emitted during cement production. Other problems include poor awareness of environmental and human health issues among the general population and the importance of fencing hazardous waste sites. However, the mine has regional support owing to the role of the mine in the regional economy and Haidarkan provides a livelihood for 1,000 miners (Novikov and others, 2008, p. 4).

Mexico.—Cinnabar mining dates to 1000 B.C. in Mexico (Consejo de Recursos Minerales, 1992, p. 21) and mercury imported from Spain and Peru was used for colonial silver processing in Mexico (Craddock, 1995, p. 216). In 2003, near Zacatecas, Mexico, there were four plants that were extracting mercury, silver, and gold from tailings that date to A.D. 1550–1900 when mercury was widely used in the amalgamation process to produce silver. It was estimated that 13,000 to 34,000 t of mercury was discarded in the extraction of silver (Ogura and others, 2003, p. 167).

Potential mercury reserves in Mexico were estimated to be 26,900 t including production from colonial tailings (14,900 t), primary mercury mines (11,700 t), and chlorine-caustic soda industry stocks (250 t). Small-scale mercury production also takes place but was not quantified. Colonial tailings are also present in the State of San Luis Potosi; however, these have not been quantified. Mexico has recovered mercury from colonial tailings, small-scale primary mercury mines, imported mercury from developed countries, and exported mercury to Argentina, Brazil, Colombia, and Peru (Castro Diaz, 2008, p. 9).

Peru.—Cinnabar was used as a pigment and the mercury was retorted and used to process gold in ancient Peru (Petersen, 1970, p. 87). Geochemical studies of lake sediment cores, combined with ^{14}C dates, by university researchers indicated that mercury was mined at Huancavelica, Peru, the largest mercury occurrence in the New World, more than 3,000 years ago (Cooke and others, 2009). After European contact, the mercury was also used for Spanish colonial silver processing; however, mining at Huancavelica stopped in the 1990s. In 2009, 92 t of byproduct mercury from Peru's large-scale mines was recovered and shipped to the United States for processing, resale, and shipment to metals dealers in Europe to ultimately be used for small-scale gold mining, as well as chlorine-caustic soda production and dental amalgam. Destinations in Latin America included Brazil, Colombia, Ecuador, Guyana, and Peru (Brooks and others, 2007, p. 35).

Outlook

Global mercury use is expected to decline with the exception of mercury used for the growing compact fluorescent lamp industry and in small-scale gold mining. Mercury has been used since ancient times for small-scale gold mining, and if gold prices continue to rise, they are expected to increase the demand for mercury used in today's worldwide, small-scale gold mining industry. Rising gold prices would also stimulate gold exploration, resulting in the opening of new large-scale mines. This would, in turn, ultimately result in continued byproduct mercury production from the processing of ore from these large-scale gold mines.

Galinstan is an alloy which is liquid at room temperatures and, owing to the low toxicity of its component metals, is a replacement for mercury. Owing to its higher reflectivity and lower density than mercury, galistan is being considered as a replacement for mercury in liquid mirror telescopes for astronomy (Metal-Pages, 2008b). Mercury dental amalgam, which is less aesthetically pleasing, was used less in favor of ceramic material with more natural colors. Closure of mercury cell chlorine-caustic soda production facilities worldwide owing to pressure from international environmental and health organizations was expected to result in release of large amounts of mercury for disposal, recycling, or storage.

Recycled mercury from mercury cell chlorine-caustic soda plants, byproduct mercury recovered from domestic and foreign gold operations, and mercury contained in the NDS are expected to be more than adequate to meet domestic needs.

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TABLE 1
SALIENT MERCURY STATISTICS[1]

(Metric tons unless otherwise specified)

		2005	2006	2007	2008	2009
United States:						
Secondary production, industrial		NA	NA	NA	NA	NA
Imports for consumption		212	94	67	155	206
Exports		319	390	84	732	753
Industry stocks, yearend[2]		38	19	18	24	30
Chloralkali		35	17	16	20	27
Other		3	2	2	4	3
Industrial consumption		40	38	31	NA	NA
Price, average, free market[3]	dollars per flask	555	670	530	600	600
World, mine production		1,520	1,150	1,200	1,320	1,920 e

e Estimated. NA Not available.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Stocks at consumer and dealers only.

[3] Source: Platts Metal Week.

TABLE 2
U.S. IMPORTS AND EXPORTS OF MERCURY, BY COUNTRY[1]

	2008		2009	
Country	Quantity, gross weight (metric tons)	Value (thousands)	Quantity, gross weight (metric tons)	Value (thousands)
Imports:				
Canada	4	$34	5	$24
Chile	--	--	88	195
China	(2)	4	--	--
Germany	14	1,070	14	970
Japan	--	--	(2)	5
Peru	136	562	92	104
Russia	--	--	7	42
United Kingdom	(2)	13	(2)	8
Other	1	13	--	--
Total	155	1,700	206	1,350
Exports:				
Australia	10	167	21	340
Brazil	4	63	(2)	7
Canada	6	54	2	15
Chile	--	--	2	62
Colombia	--	--	4	75
Guatemala	--	--	13	123
Guyana	9	151	4	15
India	26	488	107	1,280
Korea, Republic of	(2)	16	7	154
Mexico	(2)	4	10	144
Netherlands	535	6,960	414	5,560
Peru	13	227	110	1,580
Singapore	4	77	16	261
Vietnam	121	1,810	41	605
Other	4	73	2	32
Total	732	10,100	753	10,300

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

TABLE 3
U.S. IMPORTS AND EXPORTS OF AMALGAMS[1] OF PRECIOUS METALS, WHETHER OR NOT CHEMICALLY DEFINED, BY COUNTRY[2]

	2008		2009	
Country	Quantity, gross weight (metric tons)	Value (thousands)	Quantity, gross weight (metric tons)	Value (thousands)
Imports:				
Argentina	2	$25,900	1	$12,200
Germany	5	24,100	4	7,220
Italy	3	4,890	1	915
Japan	(3)	538	1	467
Mexico	1	1,190	3	6,130
United Kingdom	1	4,180	2	2,910
Other	3 r	6,080 r	2	1,420
Total	15	66,800	14	31,300
Exports:				
Canada	17	13,700	12	2,940
China	2	35,500	15	52,300
Costa Rica	2	27	10	82
Dominican Republic	18	28	(3)	35
France	1	2,690	1	6,360
Germany	25	7,920	11	14,200
Hong Kong	19	19,900	20	1,370
India	192	39,800	6	17,300
Japan	2	28,900	16	25,100
Korea, Republic of	70	7,320	5	5,460
Mexico	47	211,000	18	27,900
Netherlands	13	30,600	14	22,700
Peru	37	271	(3)	21
Singapore	23	9,260	3	4,010
Taiwan	20	38,900	1	14,000
United Arab Emirates	388	545	--	--
United Kingdom	21	32,600	4	4,950
Other	28	84,600	17	39,500
Total	925	564,000	154	238,000

r Revised. -- Zero.

[1] An alloy of mercury with one or more other metals.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Less than ½ unit.

TABLE 4
MERCURY: WORLD MINE PRODUCTION, BY COUNTRY[1,2,3]

(Metric tons)

Country	2005	2006	2007	2008	2009[e]
Algeria	(4)	--	--	--	--
China[e]	1,100	760	800	800	1,400
Finland	20	20	20	20	15
Kyrgyzstan	200	250	250	250	250
Mexico[e]	6	8	8	21	21
Morocco[e]	10	10	10	10	10
Peru, exports[5]	102	22	34 [e]	136	140 [p]
Russia[e]	50	50	50	50	50
Spain	NA	NA	NA	NA	NA
Tajikistan[e]	30	30	30	30	30
United States[5]	NA	NA	NA	NA	NA
Total	1,520	1,150	1,200	1,320	1,920

[e]Estimated. [p]Preliminary. NA Not available. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through April 20, 2010.

[3] Canada and Chile were thought to produce byproduct mercury, but information on their production was inadequate to make reliable estimates.

[4] Less than ½ unit.

[5] Byproduct mercury.

MICA

By M. Michael Miller

Domestic survey data and tables were prepared by Hoa P. Phamdang, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

Mica production decreased in 2009 compared with that of 2008. In 2009, production of scrap and flake mica in the United States decreased to 50,000 metric tons (t); this was 40% lower than that of 2008 (tables 1, 2). The quantity of ground mica sold or used by producers decreased by 21% to about 77,000 t valued at $23.2 million (tables 1, 3). Essentially all sheet mica used in the United States was imported, and Brazil, China, Belgium, Austria, and France, in decreasing order by quantity, were the major suppliers (table 11). Consumption of muscovite block mica in 2009 remained unchanged from that of 2008 at 1.0 t, although the value increased to $131,000 in 2009 from $127,000 in 2008 (tables 1, 4). Consumption of mica splittings decreased to an estimated 276 t in 2009 from 308 t in 2008 (tables 1, 5). Worked and unworked sheet mica exports decreased to 1,120 t in 2009 from 2,020 t in 2008, and the value decreased to $15.7 million in 2009 from $18.8 million in 2008 (table 8). U.S. imports of worked and unworked sheet mica decreased to 1,040 t in 2009 from 1,880 t in 2008, and the value decreased to $14.5 million in 2009 from $18.4 million in 2008 (table 12).

The mica group represents 37 phyllosilicate minerals that have a layered or platy texture (Rieder and others, 1998, p. 43–45). The commercially important micas are muscovite and phlogopite, which are used in a variety of applications. Mica's value is based on several of its unique physical properties. The crystalline structure of mica forms layers that can be split or delaminated into thin sheets. These sheets are chemically inert, dielectric, elastic, flexible, hydrophilic, insulating, lightweight, platy, reflective, refractive, resilient, and range in opacity from transparent to opaque. Mica is stable when exposed to electricity, light, moisture, and extreme temperatures. Mica has superior electrical properties as an insulator and as a dielectric. It can support an electrostatic field while dissipating minimal energy in the form of heat, can be split very thin (0.025 to 0.125 millimeters or thinner) while maintaining its electrical properties, has a high dielectric breakdown, is thermally stable to 500° C, and has corona resistance. Muscovite is the principal mica used by the electrical industry and is used in capacitors that are ideal for high frequency and radio frequency. Phlogopite mica remains stable at higher temperatures (to 900° C) and is used in applications in which a combination of high-heat stability and electrical properties are required. Muscovite and phlogopite are used in sheet and ground forms.

Production

Domestic mine production data for mica are developed by the U.S. Geological Survey from four separate voluntary surveys. Of the 12 operations to which the "Crude Scrap and Flake Mica Production" (including sericite production) survey form was sent, 6 operations responded and 1 was closed. Of the 11 operations to which the "Ground Mica" (excluding low-grade ground sericite production) form was sent, 2 operations responded and 1 was closed. Of the five surveyed operations to which the "Mica Block and Film Consumption" form was sent, two operations responded. Of the nine surveyed operations to which the "Mica Splittings Consumption" form was sent, three operations responded. Consumption for the nonrespondents was estimated using prior-year production data. Individual company production and consumption data are withheld to avoid disclosing company proprietary data.

Scrap and Flake Mica.—In 2009, eight companies with eight mines in four States produced scrap and flake mica, excluding low-grade sericite. The United States was one of the world's primary producers, with production of about 50,000 t (tables 1, 2, and 13). The major producing States were, in descending order, South Dakota, North Carolina, and Georgia. Alabama also produced mica. Mica was recovered from mica schist, high-quality sericite schist, weathered pegmatites, gemstone pegmatite (sheet only), and as a coproduct of feldspar and kaolin mining and processing operations.

In 2009, the scrap and flake mica producers were BASF Corp., Hartwell, GA; The Feldspar Corp. (an Imerys S.A. company) (two mines), Spruce Pine, NC; Georgia Industrial Minerals, Inc., Deepstep, GA; K-T Feldspar Corp., Spruce Pine; Kings Mountain Mining LLC (an Imerys S.A. company), Kings Mountain, NC; Pacer Corp., Custer, SD; Tinton Enterprises, Ltd., Spearfish, SD; and Unimin Corp., Spruce Pine.

Ground Mica.—In 2009, six companies operated nine grinding plants in three States; six plants produced dry-ground mica, and three produced wet-ground mica.

Dry-ground mica producers were Georgia Industrial Minerals, Inc., Deepstep; Kings Mountain Mining LLC; Pacer Corp.; Piedmont Minerals Corp., Hillsborough, NC; and United States Gypsum Co. (a subsidiary of USG Corp.), Spruce Pine.

Wet-ground mica producers were BASF Corp; Georgia Industrial Minerals, Inc., Sandersville, GA; and Kings Mountain Mining LLC.

Sheet Mica.—Sheet mica was produced as a byproduct from one mine in 2009. Small quantities of muscovite sheet and scrap mica were produced as a byproduct by Morefield Gem Mine, Inc. in Amelia County, VA. The pegmatite was mined primarily for gemstones and mineral specimens using underground methods. The mine also produced biotite and zinnwaldite mica for collectors.

Consumption

Ground Mica.—The leading domestic use of dry-ground mica was in joint compound for filling and finishing seams and blemishes in gypsum wallboard (drywall) (table 3). The mica acts as a filler and extender, provides smooth consistency, improves the workability of the compound, and provides resistance to cracking. In 2009, joint compound accounted for 62% of dry-ground mica consumption.

In the paint industry, ground mica is used as a pigment extender that also facilitates suspension, reduces chalking, prevents shrinking and shearing of the paint film, increases resistance of the paint film to water penetration and weathering, and brightens the tone of colored pigments. Mica also promotes paint adhesion in aqueous and oleoresinous formulations. Consumption of dry-ground mica in paint, the second ranked use, accounted for 22% of the dry-ground mica used in 2009.

Ground mica is used in the well-drilling industry as an additive to drilling muds. The coarsely ground mica flakes help prevent the loss of circulation by sealing porous sections of the drill hole. The sharp decrease in oil and gas prices in 2009 discouraged exploration. The monthly U.S. drill rig count in 2009 hit a low of 876 in late summer before recovering to 1,189 at yearend. This was still significantly lower than the 2008 yearend count of 1,721. The average monthly drill rig count for 2009 was 1,089 or nearly 800 operating rigs less than that of 2008 (Baker Hughes, 2010). These factors resulted in a sharp decrease in mica consumption in 2009 compared with that of 2008. Well drilling muds accounted for 6% of dry-ground mica use in 2009, a decrease from 15% the previous year.

The plastics industry used dry-ground mica as an extender and filler, especially in parts for automobiles as lightweight insulation to suppress sound and vibration. Mica is used in plastic automobile fascia and fenders as a reinforcing material, providing improved mechanical properties and increased dimensional stability, stiffness, and strength. Mica-reinforced plastics also have high-heat dimensional stability, reduced warpage, and the best surface properties of any filled plastic composite. In 2009, consumption of dry-ground mica in plastic applications accounted for 3% of the market.

The rubber industry used ground mica as an inert filler and mold release compound in the manufacture of molded rubber products, such as tires and roofing. The platy texture acts as an antiblocking, antisticking agent. As a rubber additive, mica reduces gas permeation and improves resiliency.

Dry-ground mica is used in the production of rolled roofing and asphalt shingles where it serves as a surface coating to prevent sticking of adjacent surfaces. The coating is not absorbed by freshly manufactured roofing because mica's platy structure is unaffected by the acid in asphalt or by weather conditions. Mica is used in decorative coatings on wallpaper, concrete, stucco, and tile surfaces. It also is used as an ingredient in flux coatings on welding rods, in some special greases, and as coatings for core and mold release compounds, facing agents, and mold washes in foundry applications.

Dry-ground phlogopite mica is used in automotive brake linings and clutch plates to reduce noise and vibration (asbestos substitute); as sound-absorbing insulation for coatings and polymer systems; in reinforcing additives for polymers to increase strength and stiffness and to improve stability to heat, chemicals, and ultraviolet (UV) radiation; in heat shields and temperature insulation; in industrial coating additive to decrease the permeability of moisture and hydrocarbons; and in polar polymer formulations to increase the strength of epoxies, nylons, and polyesters.

Wet-ground mica, which retains the brilliancy of its cleavage faces, is used primarily in pearlescent paints by the automotive industry. In the cosmetics industry, its reflective and refractive properties make mica an important ingredient in blushes, eyeliner, eyeshadow, foundation, hair and body glitter, lipstick, lip gloss, mascara, moisturizing lotions, and nail polish. Mica is added to latex balloons to provide a colored shiny surface.

Natural mica is used by the Taos and Picuris Pueblos Indians in north-central New Mexico to make pottery. The pottery is made from weathered pre-Cambrian mica schist and has flecks of mica throughout the vessels. Tewa Pueblo pottery is made by coating the clay with mica to provide a dense-glittery micaceous finish over the entire object.

Built-Up Mica.—Muscovite and phlogopite splittings were fabricated into various built-up mica products by seven companies that operated seven plants in five States. Produced by mechanized or hand setting of overlapping splittings and alternate layers of binders and splittings, built-up mica is used primarily as an electrical insulation material. Mica insulation is used in high-temperature and fire-resistant power cable in aluminum plants, blast furnaces, critical wiring circuits (for example, defense systems, fire and security alarm systems, and surveillance systems), heaters and boilers, lumber kilns, metal smelters, and tanks and furnace wiring. Specific high-temperature mica-insulated wire and cable is rated to work for up to 15 minutes in molten aluminum, glass, and steel. Major products are bonding materials; flexible, heater, molding, and segment plates; mica paper; and tape (table 6).

Flexible plate (cold) is used in electric motor and generator armatures, field coil insulation, and magnet and commutator core insulation. In 2009, mica consumption in flexible plate was an estimated 18 t, or a decrease of 14% compared with that of 2008.

Heater plate is used where high-temperature insulation is required. Consumption data for mica in heater plate are withheld to avoid disclosing company proprietary information. Consumption of heater plate mica decreased by 85% in 2009 compared with that of 2008.

Molding plate is sheet mica from which V-rings are cut and stamped for use in insulating the copper segments from the steel shaft ends of a commutator. Molding plate is also fabricated into tubes and rings for insulation in armatures, motor starters, and transformers. Consumption for molding plate decreased by nearly 34% to an estimated 43 t in 2009.

Segment plate acts as insulation between the copper commutator segments of direct-current universal motors and generators. Phlogopite built-up mica is preferred because it wears at the same rate as the copper segments. Although muscovite has a greater resistance to wear, it causes uneven ridges that may interfere with the operation of a motor or generator. Consumption of segment plate was estimated to be about 147 t in 2009, although this estimate may be high.

Some types of built-up mica have the bonded splittings reinforced with cloth, glass, linen, muslin, plastic, silk, or special paper. These products are very flexible and are produced in wide, continuous sheets that are either shipped, rolled, or cut into ribbons or tapes, or trimmed to specified dimensions.

Built-up mica products may also be corrugated or reinforced by multiple layering.

In 2009, the total amount of built-up mica that was consumed or shipped was estimated to be about 278 t. Segment plate and molding plate were the major end products and accounted for 53% and 16% of the total, respectively.

Mica Paper (Reconstituted Mica).—Primary uses for mica paper are the same as those for built-up mica. Five companies consumed scrap mica to produce mica paper for electrical and insulation applications. The principal source of the scrap was India. In 2009, the manufacturing companies were Asheville-Schoonmaker Mica Co., Newport News, VA; Corona Films Inc., West Townsend, MA; Isovolta Inc./US Samica Corp., Rutland, VT; Spruce Pine Mica Co., Spruce Pine; and Tar Heel Mica Co,, Inc., Plumtree, NC.

Sheet Mica.—Sheet mica is used principally in the electronic and electrical industries. Its usefulness in these applications is derived from its unique electrical and thermal insulating properties and its mechanical properties, which allow it to be cut, punched, stamped, and machined to close tolerances.

The leading use of block mica is as an electrical insulator in electronic equipment. High-quality block mica is processed to line the gauge glasses of high-pressure steam boilers because of its flexibility, transparency, and resistance to heat and chemical attack. Other uses include diaphragms for oxygen-breathing equipment, marker dials for navigation compasses, optical filters, pyrometers, retardation plates in helium-neon lasers, thermal regulators, and stove and kerosene heater windows. Specialized applications for sheet mica are found in aerospace components in air-, ground-, and sea-launched missile systems, laser devices, medical electronics, optical instrumentation, radar systems, radiation detector windows that are transparent to alpha emissions (Geiger-Mueller tubes), and for radiation treatment.

Only high-quality muscovite film mica, which is variously called India ruby mica or ruby muscovite mica, is used as a dielectric in capacitors. The highest quality mica film is used to manufacture capacitors for calibration standards. The next lower grade is used in transmitting capacitors. Receiving capacitors use a slightly lower grade of high-quality muscovite.

In 2009, fabrication of ruby and nonruby muscovite block consumed 1.08 t, about a 4% increase from that consumed in 2008 (table 4). Stained and lower-than-stained quality remained in greatest demand and accounted for about 62% of consumption of ruby and nonruby mica block. Consumption of nonruby mica block was 59% for stained and lower-than-stained quality and 41% for good quality.

In 2009, five companies consumed muscovite block and film at five plants in four States—two in North Carolina and one each in New Jersey, Ohio, and Virginia.

In 2009, mica splittings represented the largest part of the sheet mica industry in the United States. Consumption of muscovite and phlogopite splittings was an estimated 276 t in 2009 (table 5). Muscovite splittings from India accounted for essentially all domestic consumption. The remainder was primarily imported from Madagascar.

Stocks

In 2009, reported yearend industry stocks of muscovite mica block (ruby and nonruby) were unchanged at 14.3 t. Industry stocks of muscovite and phlogopite mica splittings at an estimated 83 t were about 3% less than the previous year's level (table 5).

Prices

Sheet mica prices vary with grade and can range from less than $1 per kilogram for low-quality mica to more than $2,000 per kilogram for the highest quality. The estimated average values of mica block and splittings consumed in the United States in 2009 were as follows—muscovite block (ruby and nonruby) was $120 per kilogram and muscovite and phlogopite splittings were $1.60 per kilogram (tables 1, 5). Phlogopite block was $115 per kilogram and phlogopite splittings were $21 per kilogram.

In 2009, the average U.S. value of scrap and flake mica, which included high-quality sericite, was estimated to be $140 per metric ton (table 2). The average value for North Carolina flake mica was estimated to be $277 per ton. The average value of dry-ground mica was estimated to be $284 per ton, and the average value of wet-ground mica was estimated to be $651 per ton (table 1).

Foreign Trade

The value of U.S. exports of mica decreased by 4% to $26.2 million, and the quantity decreased by 18% to 9,150 t (table 12). U.S. exports of mica excluding unworked sheet mica decreased by 5% in value from those of 2008 to $25.8 million, while the quantity decreased by 18% to 9,050 t.

Domestic ground mica (powder) exports decreased to 5,940 t, a decrease of 690 t from that of 2008 (tables 7, 12). Ground mica exports increased in value to $8.85 million in 2009 from $7.81 million in 2008. Exports of crude and rifted mica increased by 40% to 688 t in 2009 from 490 t in 2008. The value of these exports increased even more dramatically (up nearly 240%) to $1.48 million in 2009 from $436,000 in 2008 (table 7).

U.S. imports of all mica totaled 21,000 t valued at $25.8 million, decreases of 26% and 20%, respectively, compared with those of 2008. U.S. imports of mica excluding unworked mica scrap (less than $1.00 per kilogram) decreased by 26% in quantity to 19,500 t and decreased by 21% in value to $24.8 million from those of 2008.

In 2009, total imports for consumption of unworked split block, film, splittings, and mica sheet categorized as "Other" decreased by nearly 16% to about 1,900 t, almost all of which was comprised of unworked low-value scrap mica (less than $1.00 per kilogram) (table 9). Demand weakened for the low-value mica used as a dry-ground additive for drywall compound, fillers, and paints.

In 2009, 16,900 t of powder mica was imported, mostly from Canada and China, about 6,500 t less than in 2008 (table 10).

Worked mica imports were 1,480 t, a 42% decrease from those of 2008 (table 11).

World Review

World production of mica was estimated to have decreased to 315,000 t in 2009 from 379,000 t in 2008. Countries for which reported data were available all reported decreases in production in 2009 compared with that of 2008. Data were unavailable for the two leading producers—Finland and Russia—but the Republic of Korea, which accounted for 13% of production in 2008, reported a decrease in production of 45% in 2009 (table 13).

Outlook

The major markets for ground mica—drywall joint compounds and paints—are mature and relatively stable, with growth tied to new housing starts and interest rates. When the housing market recovers, the long-term outlook for ground mica is for an expected production growth of 1% to 3% per year. Demand is also affected by automobile production because interior and exterior parts typically contain dry-ground mica or engineered mica composites, and exterior surfaces are painted with wet-ground pearlescent pigments and mica-containing coatings. The North American automobile industry rebounded much quicker than housing, and vehicle production was forecast to grow at about 7% in 2011 (Thomson Reuters, 2011).

As the economy recovers, demand for ground mica in smaller specialty markets such as coated micas, cosmetics, nylon and polyester resins, and polypropylene composites was expected to resume annual growth at a rate slightly higher than the rate for the entire ground mica industry during the next decade.

Demand for block mica was expected to increase slowly at about 1% per year during the next several years as demand increases in a few specialty markets, such as electronics. A shortage of high-quality block mica was expected to continue because of the generally low percentage of high-quality mica in deposits currently being mined, mostly pegmatites.

Consumption of mica splittings, which is the principal type of sheet mica consumed in the United States, has been in the range of 300 to 400 metric tons per year (t/yr) in recent years, although it was estimated to have dipped below 300 t/yr in 2009. With no potential new uses apparent and many substitute materials being used, substantial growth is not expected.

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TABLE 1
SALIENT MICA STATISTICS[1]

		2005	2006	2007	2008	2009
United States:						
Production, sold or used by producers:						
Scrap and flake mica:						
Quantity	thousand metric tons	78	110	97	84	50
Value	thousands	$19,300	$22,400	$14,400	$12,000 [r]	$7,040
Ground mica:						
Quantity	thousand metric tons	120	123	99	98	77
Value	thousands	$47,200	$49,000	$26,400	$26,500	$23,200
Prices:						
Scrap and flake mica	dollars per metric ton	248	204	149	143	140
Ground:						
Dry	do.	226	237	243	251	284
Wet	do.	776	784	683	651	651
Sheet, muscovite and phlogopite:						
Block	dollars per kilogram	125	130	132	122	120
Splittings	do.	1.56	1.53	1.57	1.53 [e]	1.60 [e]
Consumption:						
Block, muscovite:						
Quantity	metric tons	1	1	1	1	1
Value	thousands	$134	$146	$139	$127	$131
Splittings, all types						
Quantity	metric tons	402	310	310	308 [e]	276 [e]
Value	thousands	$626	$475	$475	$471 [e]	$442 [e]
Exports	metric tons	10,800	8,620	9,010	11,100	9,150
Imports	do.	38,800	46,900	43,000	28,800	21,400
World, production	do.	359,000	385,000 [r]	387,000 [r,e]	379,000 [r,e]	315,000 [e]

[e]Estimated. [r]Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits.

TABLE 2
SCRAP AND FLAKE MICA SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1, 2]

(Thousand metric tons and thousand dollars)

	2008		2009	
State	Quantity	Value	Quantity	Value
North Carolina	22	4,580	16	4,430
Other[3]	62	7,430 [r]	34	2,610
Total	84	12,000 [r]	50	7,040

[r]Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes finely divided mica recovered from mica schist and high-quality sericite schist, and mica that is a byproduct of feldspar and kaolin beneficiation.

[3] Includes Alabama, Georgia, and South Dakota.

TABLE 3
GROUND MICA SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY END USE AND METHOD OF GRINDING[1, 2]

	2008			2009		
	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value
End use:						
Joint compound	53	$12,800	$246	47	$12,200	$256
Paint	22	7,180	324	17	6,440	384
Plastics	2	1,390	697	2	1,360	642
Well-drilling mud	15	2,790	181	5	943	191
Other[3]	6	2,320	386	6	2,290	381
Total	98	26,500	271	77	23,200	301
Method of grinding:						
Dry	W	W	251	W	W	284
Wet	W	W	651	W	W	651

W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Domestic and some imported scrap. Low-quality sericite is not included.

[3] Includes mica used for molded electrical insulation, roofing, rubber, textile and decorative coatings, welding rods, and miscellaneous.

TABLE 4
FABRICATION OF MUSCOVITE BLOCK MICA IN THE UNITED STATES, BY QUALITY[1]

(Kilograms)

	2008	2009
Good stained or better	420	416
Stained or lower than stained[2]	624	665
Total	1,040	1,080

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes punch mica.

TABLE 5
ESTIMATED CONSUMPTION AND STOCKS OF MICA SPLITTINGS IN THE UNITED STATES

	Consumption		
Year	Quantity (metric tons)	Value (thousands)	Stocks on December 31 (metric tons)
2008	308	$471	86
2009	276	442	83

TABLE 6

ESTIMATED BUILT-UP MICA SOLD OR USED IN THE UNITED STATES, BY PRODUCT[1, 2]

	2008		2009	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Flexible plate (cold)	21	$173	18	$150
Heater plate	W	W	W	W
Molding plate	65	431	43	313
Segment plate	149	288	147	278
Tape	W	W	W	W
Other	116	539	70	248
Total	351	1,430	278	989

W Withheld to avoid disclosing company proprietary data; included in "Other."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Consists of alternating layers of binder and irregularly arranged and partly overlapped splittings.

TABLE 7

U.S. EXPORTS OF CRUDE AND RIFTED MICA, MICA POWDER, AND WASTE IN 2009, BY COUNTRY[1]

Country	Crude and rifted: Less than $1 per kilogram: Quantity (metric tons)	Crude and rifted: Less than $1 per kilogram: Value (thousands)	Crude and rifted: More than $1 per kilogram: Quantity (metric tons)	Crude and rifted: More than $1 per kilogram: Value (thousands)	Powder: Quantity (metric tons)	Powder: Value (thousands)	Waste: Quantity (metric tons)	Waste: Value (thousands)
Albania	--	--	(2)	$7	--	--	--	--
Algeria	--	--	--	--	313	$180	--	--
Argentina	--	--	--	--	22	151	--	--
Australia	--	--	--	--	(2)	3	--	--
Bahamas, The	307	$67	8	26	--	--	--	--
Barbados	9	7	--	--	4	13	--	--
Belgium	--	--	--	--	490	933	--	--
Belize	--	--	--	--	12	28	--	--
Brazil	--	--	--	--	103	438	--	--
British Virgin Islands	--	--	1	5	--	--	--	--
Canada	8	3	--	--	1,260	1,370	1,470	$460
China	--	--	7	33	123	190	--	--
Colombia	--	--	1	15	393	732	--	--
Costa Rica	--	--	--	--	5	15	--	--
Czech Republic	--	--	--	--	2	9	--	--
Dominica	--	--	--	--	12	16	--	--
Dominican Republic	--	--	--	--	20	3	--	--
El Salvador	--	--	--	--	11	5	--	--
Finland	--	--	--	--	7	35	--	--
France	--	--	--	--	86	386	20	5
Germany	--	--	21	33	126	513	--	--
Guatemala	--	--	--	--	13	11	--	--
Honduras	--	--	--	--	2	30	--	--
Hong Kong	--	--	--	--	10	44	--	--
Indonesia	--	--	--	--	28	40	--	--
Ireland	--	--	--	--	8	17	--	--
Italy	--	--	3	9	59	32	7	100
Japan	--	--	32	89	156	311	--	--
Korea, Republic of	20	9	--	--	607	500	--	--
Malaysia	--	--	--	--	9	19	--	--
Mexico	5	3	--	--	1,480	853	--	--
Montenegro	--	--	--	--	16	9	--	--
Netherlands	--	--	--	--	156	559	--	--
New Zealand	--	--	--	--	23	11	(2)	4
Pakistan	--	--	--	--	15	66	--	--
Peru	--	--	--	--	6	78	--	--
Philippines	--	--	--	--	88	66	--	--
Poland	--	--	--	--	19	20	--	--
Saint Lucia	--	--	--	--	3	6	--	--
Saudi Arabia	--	--	--	--	87	123	--	--
Singapore	--	--	--	--	27	78	--	--
South Africa	--	--	--	--	54	8	--	--
Spain	--	--	--	--	17	20	--	--
Taiwan	--	--	1	3	6	51	--	--
Thailand	20	16	--	--	--	--	--	--
Trinidad and Tobago	--	--	236	1,080	--	--	--	--
United Kingdom	--	--	9	65	49	264	--	--
Uruguay	--	--	--	--	1	3	--	--
Venezuela	--	--	--	--	16	608	--	--
Total	369	105	319	1,370	5,940	8,850	1,500	569

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.
[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8
U.S. EXPORTS OF WORKED MICA IN 2009, BY COUNTRY[1]

Country	Plates, sheets		Other	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Afghanistan	9	$43	--	--
Australia	3	93	1	$44
Austria	1	15	270	1,700
Bahamas, The	1	9	1	5
Bahrain	--	--	(2)	3
Belgium	4	105	(2)	30
Brazil	19	391	4	147
Canada	70	2,280	62	1,650
Chile	(2)	18	--	--
China	8	244	31	670
Colombia	25	541	2	42
Costa Rica	--	--	(2)	3
Czech Republic	(2)	11	--	--
Dominican Republic	5	39	(2)	7
Ecuador	3	11	--	--
El Salvador	2	12	--	--
France	44	1,910	2	69
Germany	19	251	(2)	8
Guatemala	1	29	--	--
Honduras	2	6	--	--
Hong Kong	(2)	4	(2)	7
India	13	391	2	54
Israel	202	512	--	--
Italy	19	270	3	86
Jamaica	7	42	--	--
Japan	3	30	1	33
Korea, Republic of	14	151	(2)	7
Malaysia	(2)	4	(2)	3
Mexico	26	572	16	631
Morocco	--	--	1	29
Namibia	--	--	(2)	11
Netherlands	1	25	--	--
Netherlands Antilles	2	8	--	--
Nicaragua	--	--	(2)	11
Pakistan	--	--	(2)	4
Peru	4	17	--	--
Philippines	--	--	(2)	12
Poland	--	--	(2)	25
Qatar	--	--	(2)	11
Saint Lucia	1	5	--	--
Saudi Arabia	13	51	4	40
Singapore	(2)	4	1	19
South Africa	(2)	4	1	23
Spain	(2)	14	(2)	7
Sri Lanka	3	9	--	--
Switzerland	4	92	(2)	21
Taiwan	25	438	10	833
Thailand	(2)	6	(2)	8
Trinidad and Tobago	9	33	--	--
Turkey	1	3	(2)	7
United Arab Emirates	2	41	--	--
United Kingdom	30	175	1	38
Uruguay	1	16	--	--

See footnotes at end of table.

TABLE 8—Continued

U.S. EXPORTS OF WORKED MICA IN 2009, BY COUNTRY[1]

Venezuela	3	82	(2)	3
Vietnam	--	--	1	8
Other	6	(2)	3	(2)
Total	601	9,000	417	6,310

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9

U.S. IMPORTS FOR CONSUMPTION OF CRUDE AND RIFTED MICA IN 2009, BY COUNTRY[1]

					Other			
	Split block		Splittings		Less than $1 per kilogram		More than $1 per kilogram	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Belgium	--	--	--	--	--	--	(2)	$23
Canada	(2)	$3	--	--	--	--	--	--
China	--	--	--	--	--	--	2	10
India	(2)	14	20	$67	1,810	$999	--	--
Turkey	--	--	--	--	96	33	--	--
Total	(2)	17	20	67	1,900	1,030	2	33

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 10

U.S. IMPORTS FOR CONSUMPTION OF MICA POWDER AND WASTE IN 2009, BY COUNTRY[1]

	Powder		Waste	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Argentina	23	$10	--	--
Canada	7,840	3,190	(2)	$6
China	6,650	1,270	18	11
Finland	1,340	343	--	--
France	31	34	--	--
Germany	126	242	--	--
India	173	158	1,070	645
Italy	1	38	--	--
Japan	617	4,030	--	--
Korea, Republic of	1	11	--	--
Malaysia	32	82	--	--
Mexico	33	26	--	--
Norway	64	68	--	--
South Africa	1	2	--	--
United Kingdom	12	38	--	--
Total	16,900	9,540	1,090	662

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 11

U.S. IMPORTS FOR CONSUMPTION OF WORKED MICA IN 2009, BY COUNTRY[1]

Country	Plates, sheets Quantity (metric tons)	Plates, sheets Value (thousands)	Other Quantity (metric tons)	Other Value (thousands)
Australia	2	$62	(2)	$3
Austria	128	2,940	30	893
Belgium	200	2,580	--	--
Brazil	216	1,020	238	423
Canada	(2)	24	--	--
China	288	1,710	26	207
Czech Republic	(2)	3	--	--
France	96	891	(2)	9
Germany	66	1,150	2	127
Hong Kong	10	60	(2)	3
India	51	331	74	586
Italy	--	--	9	23
Japan	10	457	(2)	49
Korea, Republic of	2	33	--	--
Mexico	(2)	15	--	--
Philippines	--	--	(2)	2
South Africa	(2)	7	--	--
Sweden	--	--	(2)	14
Switzerland	11	299	(2)	6
Taiwan	--	--	3	23
United Kingdom	15	403	2	84
Total	1,100	12,000	385	2,450

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 12

SUMMATION OF U.S. MICA TRADE DATA[1]

	Scrap and flake mica				Sheet mica			
	Powder		Waste		Unworked		Worked	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Exports:								
2008	6,630	$7,810	2,430	$731	105	$238	1,920	$18,600
2009	5,940	8,850	2,090	1,600	96	437	1,020	15,300
Imports for consumption:								
2008	23,400	12,300	3,560	1,470	130	465	1,750	17,900
2009	16,900	9,540	2,990	1,670	23	142	1,020	14,400

[1] Data are rounded to no more than three significant digits.

Source: U.S. Census Bureau.

TABLE 13
MICA: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007[e]	2008[e]	2009[e]
Argentina, all grades	4,101	6,233	10,171 [4]	8,790 [r, 4]	8,668 [4]
Brazil[e]	4,000	4,000	4,000	4,000	4,000
Canada[e]	17,500	17,500	18,000	17,000	15,000
Finland:					
Concentrate	9,473	8,097	8,000	8,000	8,000
Biotite	59,381	62,959	60,000	60,000	60,000
Total	68,854	71,056	68,000	68,000	68,000
France[e]	10,000	20,000	20,000	20,000	20,000
India:[e]					
Crude	1,600	1,700	1,700	1,700	1,800
Scrap and waste	2,100	2,200	2,200	2,300	2,300
Total	3,700	3,900	3,900	4,000	4,100
Iran[e, 5]	7,000	-- [r]	1,800 [r]	1,800 [r]	1,800
Korea, Republic of, all grades	36,623	30,356	42,385 [4]	49,474 [r]	27,078 [4]
Madagascar, phlogopite	546 [r]	1,071 [r]	1,349 [4]	1,233 [r, 4]	358 [4]
Malaysia	4,542	5,152	6,118 [4]	5,593 [r, 4]	4,323 [4]
Mexico, all grades	120	150	150	150	150
Norway, flake[e]	2,700	2,600	2,600	2,600	2,600
Peru	51	61	60	91 [4]	84 [4]
Russia[e]	100,000	100,000	100,000	100,000	100,000
Serbia	200 [6]	200 [e]	200	200	200
South Africa, ground and scrap	922	828	437 [4]	393 [r, 4]	299 [4]
Spain	10,000	4,496	4,500	4,500	4,500
Sri Lanka, scrap[e]	1,700	2,600 [r, 4]	3,224 [r, 4]	3,600 [r]	3,500
Taiwan	8,608	4,841	3,387 [4]	3,179 [4]	557 [4]
United States, scrap and flake[7]	78,100	110,000	96,600 [4]	84,000 [4]	50,100 [4]
Grand total	359,000	385,000 [r]	387,000 [r]	379,000 [r]	315,000

[e] Estimated. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through January 12, 2011.

[3] In addition to the countries listed, China, Pakistan, Romania, and Sweden are known to produce mica, but available information is inadequate to make reliable estimates of output levels.

[4] Reported figure.

[5] Year beginning March 21 of that stated.

[6] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[7] Excludes, if any, U.S. production of low-quality sercite and sheet mica.

MOLYBDENUM

By Désirée E. Polyak

Domestic survey data and tables were prepared by Raymond I. Eldridge III, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In the United States, mine production of molybdenum concentrate in 2009 decreased by 8,120 metric tons (t) to 47,800 t from that of 2008 (table 1). World mine production of molybdenum in 2009 was about 221,000 t, a slight increase from 218,000 t in 2008. The U.S. share of world production was about 22% in 2009. Reported U.S. consumption of molybdenum concentrate for roasting in 2009 decreased compared with that of 2008.

Molybdenum is a refractory metallic element used principally as an alloying agent in cast iron, steel, and superalloys to enhance hardenability, strength, toughness, and wear- and corrosion-resistance. To achieve desired metallurgical properties, molybdenum, primarily in the form of molybdic oxide (MoO_3, called MoX) or ferromolybdenum (FeMo), is frequently used in combination with or added to chromium, manganese, nickel, niobium (columbium), tungsten, or other alloy metals. The versatility of molybdenum in enhancing a variety of alloy properties has ensured it a significant role in contemporary industrial technology, which increasingly requires materials that can sustain high stress, expanded temperature ranges, and highly corrosive environments. There is significant use of molybdenum as a refractory metal and in numerous chemical applications, including catalysts, lubricants, and pigments.

U.S. molybdenum reserves were estimated to be about 2.7 million metric tons (Mt), about 31% of the world molybdenum reserves. About 90% of U.S. reserves occur in large low-grade porphyry molybdenum deposits mined or anticipated to be mined primarily for molybdenum and as an associated metal sulfide in low-grade porphyry copper deposits. These deposits are in Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, and Utah. Other molybdenum sources do not contribute significantly to U.S. reserves.

Production

Domestic molybdenum production data were derived from three separate voluntary surveys by the U.S. Geological Survey. These surveys are "Molybdenum Ore and Concentrate" (annual), "Molybdenum Concentrate" (monthly), and "Molybdenum Products and Molybdenum Concentrates" (monthly). Surveys were sent to all 12 U.S. operations that produce molybdenum concentrates and products from ore, and all responded, representing 100% of the U.S. production listed in table 1.

As of December 31, 2009, U.S. rated capacity for mines and mills was estimated to be about 73,200 metric tons per year (t/yr) of contained metal. Rated capacity was defined as the maximum quantity of product that could be produced in a period of time at a normally sustainable long-term operating rate based on the physical equipment of the plant and given acceptable routine operating procedures involving energy, labor, maintenance, and materials. Capacity included operating plants temporarily closed; that could be brought into production within a short period of time with minimal capital expenditure.

Primary molybdenum production continued at the Ashdown Mine in Nevada, the Henderson Mine in Colorado, the Questa Mine in New Mexico, and the Thompson Creek Mine in Idaho. The Ashdown Mine in Humboldt County, was placed on care and maintenance in November 2008 but resumed production in April 2009. In May, Golden Phoenix Minerals Inc. announced the sale of its interest in the Ashdown Mine to Win-Eldrich Mines Ltd. (Golden Phoenix Minerals Inc., 2009).

In February, Chevron Mining Inc. cut its workforce by 55% at its Questa Mine in northern New Mexico and announced that its molybdenum production would decrease accordingly. Questa has a production capacity of approximately 2,720 t/yr of molybdenum. Production capacity during the past several years has averaged about 1,800 t/yr of molybdenum. The size of the recent workforce reduction suggested that the company may be planning for an output of approximately 900 t/yr of molybdenum in 2009 (Metal-Pages, 2009i).

In April, Freeport-McMoRan Copper & Gold Inc. (FCX) announced that it expected to cut production to 40% of 2008 output levels (18,140 t) at its Henderson Mine. According to the company, Henderson has the capacity to produce approximately 18,100 t/yr of molybdenum. Most of the molybdenum concentrate produced at Henderson was shipped to a processing facility of FCX in Fort Madison, IA (Freeport-McMoRan Copper & Gold Inc., 2010, p. 15).

FCX announced that first quarter consolidated molybdenum sales from the Henderson Mine and its copper molybdenum mines totaled 4,535 t of molybdenum, a 50% decrease from those of the first quarter of 2008. FCX attributed this major decrease mainly to the reduced global demand from the metallurgical sector outside of China. FCX expected 2009 molybdenum sales from its mines to total 22,700 t of molybdenum compared with its January estimate of 27,200 t of molybdenum (Metal-Pages, 2009e).

FCX announced that it expected to double annual production to 27,200 t of molybdenum at its idle Climax molybdenum mine, without setting a date for restart. Production at the Climax Mine was originally expected to begin in 2010, but the mine has been under care and maintenance since 1995. FCX has spent $350 million on the project, establishing a mill and other facilities since acquiring the mine after a merger with former owner Phelps Dodge Inc. in 2007 (Metal Pages, 2009d).

Thompson Creek Metals Company Inc. (TCMC) owns the Thompson Creek open pit molybdenum mine and mill in Idaho, a metallurgical roasting facility in Langeloth, PA, and a 75% share of the Endako open pit mine, mill, and roasting facility in northern British Columbia, Canada. TCMC had two high-grade underground molybdenum deposits, the Davidson deposit near Smithers, British Columbia, Canada, and the Mount Emmons deposit near Crested Butte, CO.

TCMC announced that its Thompson Creek Mine produced 8,075 t of molybdenum compared with 7,620 t of molybdenum in 2008. Higher ore grade and a higher milling recovery rate during 2009 were the primary factors contributing to the increased production volumes in 2009 compared with those of 2008. The higher grade and recovery rate offset lower tonnage mined and milled. The lower tonnage milled was primarily the result of a planned change in the mill operating schedule. At the end of February, mill operation at the Thompson Creek Mine was reduced to a 10-day-on, 4-day-off operating schedule to adjust for the economic downturn. In September, the mill schedule changed to 11-days-on, 3-days-off, and in January 2010, the mill operating schedule returned to a full 7-day, 24-hour schedule (Thompson Creek Metals Company Inc., 2010, p. 16, 59).

TCMC reevaluated its reserves at the Thompson Creek Mine and as a result, increased the proven and probable mineral reserves by 29,030 t, or 30%, and increased the life of the mine to 16 years. TCMC expected molybdenum production volumes at the Thompson Creek Mine to be between 13,000 t and 14,500 t of molybdenum in 2010 (Thompson Creek Metals Company Inc., 2010, p. 6–7, 47).

TCMC had also been involved in the Mount Emmons exploration project in Gunnison County, CO. According to the company, the Mount Emmons project has one of the largest, highest grade (0.438% molybdenum) undeveloped molybdenum deposits in the world (Thompson Creek Metals Company Inc., 2010, p. 15). The company expected to complete a prefeasibility study in 2010.

Molybdenum was produced as a byproduct of copper production at the Bagdad, Mineral Park, and Sierrita Mines in Arizona; the Continental Pit Mine in Montana; and the Bingham Canyon Mine in Utah (table 10). The Morenci and Mission Mines in Arizona as well as the Chino Mine in New Mexico did not produce molybdenum in 2009. FCX placed the Chino Mine on care-and-maintenance status in December 2008. In the case of byproduct molybdenum recovery at a copper mine, all mining costs associated with producing the molybdenum concentrate are allocated to the primary metal (copper). Owing to this cost advantage, byproduct molybdenite recovery at selected porphyry copper mines was estimated to account for about 57% of the U.S. molybdenum supply in 2009.

The Sierrita operation of FCX includes a 102,000 metric-ton-per-day (t/d) concentrator that produces copper and molybdenum concentrates. It also has molybdenum facilities consisting of a leaching circuit, two molybdenum roasters, and a packaging facility. The molybdenum facilities process concentrate from Sierrita, concentrate from other FCX mines, and concentrate from third-party sources. Molybdenum production at Sierrita in 2009 was 8,620 t of molybdenum (Freeport-McMoRan Copper & Gold Inc., 2010, p. 11).

The Bagdad operation of FCX includes a 75,000-t/d concentrator that produces copper and molybdenum concentrates, as well as a pressure leach plant that processes molybdenum concentrate. Molybdenum production at Bagdad in 2009 was 2,720 t (Freeport-McMoRan Copper & Gold Inc., 2010, p. 12.)

Rio Tinto plc announced that molybdenum concentrate production at its Bingham Canyon Mine (operated by Kennecott Utah Copper) was 11,300 t of molybdenum compared with 10,600 t of molybdenum in 2008 (Rio Tinto plc, 2010, p. 68). Exploration at the Bingham Canyon Mine identified a new copper-molybdenum-gold porphyry system beneath the current open pit. The molybdenum deposit was expected to be between 450 Mt and 550 Mt of molybdenum at a grade of 0.1% to 0.15% molybdenum. The average grade of the molybdenum in the open pit reserve was 0.045% molybdenum. According to the company, current ore reserves were expected to enable open pit operations to continue until 2020 (Rio Tinto plc, 2010, p. 42).

Construction of a molybdenum autoclave process (MAP) at the Kennecott facility, approved during the second quarter of 2008, continued to be delayed owing to decreased molybdenum prices. The MAP was expected to enable lower-grade concentrate to be processed more efficiently than in conventional roasters, allow improved molybdenum recovery, and enable production of chemical-grade molybdenum products (Rio Tinto plc, 2010, p. 40).

General Moly Inc. announced that owing to the economic downturn and the continued uncertainty in the project finance market, it implemented a cash conservation plan to reduce expenditures for the development of the Mount Hope project in central Nevada. The company announced that once financing and all the necessary operating permits were obtained, it expected that the Mount Hope project could be constructed and in production within 20 months. According to the company, the Mount Hope project is one of the largest, highest grade, and most valuable undeveloped molybdenum projects in the world, containing 589,670 t of molybdenum in proven and probable reserves (General Moly Inc., 2010, p.11).

Consumption

In 2009, U.S. consumption of molybdenum contained in concentrate for roasting was less than that of 2008 (table 1). Domestic mine production of molybdenum concentrate was roasted, exported for conversion, or purified to lubricant-grade molybdenum disulfide (MoS_2). Technical-grade MoX consumption in 2009 was 9% less than that of 2008. MoX was the leading form of molybdenum used by industry, particularly in making stainless steel. Overall, total steel use in 2009 decreased by 19% from that of 2008, and total superalloy consumption decreased in 2009 by 22% from that of 2008 (table 3).

Metallurgical applications dominated molybdenum use in 2009, accounting for about 87% of 2009 grand total reported consumption (table 3). In 2009, FeMo accounted for 34% of the molybdenum-bearing materials used to make steel. Nonmetallurgical applications included catalysts, chemicals, lubricants, and pigments. The dominant nonmetallurgical use was in catalysts.

Molybdenum is playing a larger role in green technology than ever before, its use being focused on biofuels and ethanol, solar panels, and wind power. A new type of solar panel, copper-indium- gallium-selenide (CIGS) cells, utilizes molybdenum in a thin layer near the bottom of the cell. The molybdenum helps to transfer the electricity generated from the solar cell to circuits external to the panel. Although photovoltaic solar power capacity is still small, CIGS technology has demonstrated the highest conversion efficiency and the longest product life within the solar power industry. Analysts estimate that CIGS cells utilize approximately 1,100 t of molybdenum per gigawatt of capacity (General Moly Inc., 2008).

Stocks

At yearend 2009, producer plus consumer industry stocks contained 5,250 t of molybdenum, a decrease of 40 t compared with the revised yearend 2008 stocks. Inventories of molybdenum in concentrate at mines and plants increased by about 720 t. Producer stocks of molybdenum in FeMo, molybdates, MoX, metal powders, and other products decreased by about 20 t compared with the revised producer stocks of 2008 (table 2). Total stocks of about 7,670 t represented about a 22-week supply. Supply was calculated as reported stocks divided by annual consumption (table 1).

Prices

Prices were reported in Platts Metals Week in dollars per pound of contained molybdenum. In September 2008, the average prices for MoX and FeMo were almost $33 per pound and $36 per pound, respectively. Prices declined dramatically during the remainder of 2008 and the first four months of 2009, reaching a low of $7.70 per pound MoX and $8.60 per pound FeMo in April 2009. During June through August 2009, the price of MoX and FeMo rose sharply, reaching a year-to-date high of $18.30 per pound MoX and $20.00 per pound FeMo in August 2009. The prices of MoX and FeMo were volatile during the remainder of 2009, with an average price of $11.52 per pound MoX and $13.71 per pound FeMo for the fourth quarter of 2009 and $11.29 per pound of MoX and $13.10 per pound FeMo for the month of December 2009.

Foreign Trade

In 2009, molybdenum-containing material exports collectively contained about 15,100 t of molybdenum (gross weight) and were valued at $942 million (table 6). Imports for consumption of molybdenum-containing products collectively contained about 19,000 t of molybdenum (gross weight) and were valued at $269 million (table 9).

World Review

World molybdenum reserves and production capacity were concentrated in a few countries. World mine output in 2009 was estimated to have been 221,000 t (molybdenum contained in concentrate), of which, in descending order of production, China, the United States, Chile, Peru, and Canada provided about 89% (table 11). China and Canada were among the countries to increase molybdenum production from 2008 to 2009.

In North America, most Canadian reserves of molybdenum were contained in porphyry molybdenum and porphyry copper-molybdenum deposits in British Columbia. Other Canadian reserves were associated with minor porphyry copper-molybdenum deposits in New Brunswick and Quebec. The La Caridad porphyry copper-molybdenum deposit in Mexico was a leading producer. Molybdenum reserves in Central America and South America were associated mainly with large porphyry copper deposits. Of several such deposits in Chile, the Chuquicamata and El Teniente deposits were among the largest in the world and accounted for 85% of molybdenum reserves in Chile. Peru also had substantial reserves. Reserves of molybdenum in China and the Commonwealth of Independent States (CIS) were thought to be substantial, but definitive information about the current sources of supply or prospects for future development in these two areas was lacking.

Armenia.—Cronimet Mining GmbH (Germany) announced in July that it would resume expansion of the largest molybdenum-bearing deposit in the CIS, the Karajan copper-molybdenum mine managed by Zangezur Copper and Molybdenum Combine AG. The expansion project would increase production to approximately 14 Mt of molybdenum and copper concentrate in 2011, from approximately 12 Mt in 2008. According to the company, 50% of molybdenum production at Zangezur was sold to Asian countries (Metal-Pages, 2009c).

Agarak Copper and Molybdenum Combine (ACMC) in the southern Armenian Province of Syunik produced approximately 248 t of molybdenum concentrate. Owing to the economic downturn, the mine was idle for 5 months starting in February. GeoProMining Ltd. obtained shares of ACMC in 2007 and has begun implementing a reconstruction program to increase the extraction and processing of both copper and molybdenum ores at its mine (Metals Place, 2010).

Australia.—In November, Ivanhoe Mines Ltd. announced results from its initial resource estimate for the high-grade Merlin molybdenum and rhenium deposit, which comprises the Mt. Dore project in the Cloncurry District in northwestern Queensland, part of Ivanhoe Australia Ltd. At a cutoff grade of 0.4% molybdenum, estimated indicated resources total 5.2 Mt at a grade of 1.0% molybdenum and 16 grams per ton of rhenium, containing 52,000 t of molybdenum and 83 t of rhenium. Mt. Dore is a deposit containing copper, cobalt, gold, lead, molybdenum, rhenium, silver, and zinc within the Kuridala Formation. In December 2008, a drilling program in the northern part of the Mt. Dore area intersected significant molybdenum-rhenium mineralization. This mineralization represents a new discovery, now known as the Merlin deposit (Ivanhoe Mines Ltd., 2009).

In November, Moly Mines Ltd. announced that molybdenum production at its Spinifex Ridge molybdenum project in Western Australia was expected to start within 18 months after arrangement and approval of capital expenditure and financing. Hanlong Mining Investment Pty Ltd. (a subsidiary of Sichuan Hanlong Group Ltd.) was expected to invest $200 million in the company. Under the terms of the deal, Hanlong would get 207.1 million Moly Mines shares for $140 million and would provide Moly Mines with a 10-year, $60 million working capital fund, which would be used to repay interim debt (Metal-Pages, 2009h).

Canada.—Roca Mines Inc. announced molybdenum production of approximately 1,080 t of molybdenum concentrate at its Max molybdenum mine near Trout Lake, British Columbia, from August 2008 to August 2009. The company reported production revenues of $26 million for the same time period, during which it made the transition from an exploration company to a molybdenum mining company. Roca Mines sells the molybdenum concentrates produced at its Max molybdenum mine to a British-based buyer (Roca Mines Inc., 2009).

In July, Adanac Molybdenum Corp. announced that its application to remain under protection from creditors had been extended for a third time until the end of August. The company filed for bankruptcy protection under Canadian laws, citing cash flow problems in December 2008. The company announced that its Ruby Creek molybdenum project near Atlin, British Columbia, had estimated measured resources of 43.6 Mt at an average grade of 0.078% molybdenum, with 34,200 t of contained molybdenum. Development costs for the project were estimated to be approximately $550 million (Metal-Pages, 2009a).

TCMC announced in August that the Endako Mine expansion project that was postponed in December 2008, owing to the economic downturn, was approved to resume. The Endako Mine is a fully integrated facility that includes a concentrator and a roasting facility. It is located near Fraser Lake, approximately 160 kilometers (km) northwest of Prince George, British Columbia. The expansion project was expected to include the construction of a new, modern mill, which would replace the existing 45-year-old mill and would raise ore processing capacity from the existing 31,000 t/d of molybdenum to 55,000 t/d of molybdenum. Annual molybdenum production, as a result of the expansion, was expected to be approximately 6,800 t to 7,260 t of molybdenum. Construction of the new mill building and installation of new processing equipment was expected to be completed by the end of 2011 (Thompson Creek Metals Company Inc., 2009).

Taseko Mines Ltd. announced that it produced 285 t of molybdenum in 2009 at its Gibraltar Mine located in south-central British Columbia. According to the company, the mine was undergoing a $250 million expansion and modernization that was expected to increase production to 635 t/yr of molybdenum. The company expected the project to be finished by the fourth quarter of 2010 (Taseko Mines Ltd., 2010).

Chile.—Molybdenum production rose to 34,954 t of molybdenum in 2009, a 3.9% increase compared with that of 2008. Corporación Nacional del Cobre de Chile (Codelco), the state-controlled copper and molybdenum producer, announced that it produced 21,500 t of molybdenum in 2009, a 2.4 % increase from the 21,000 t of molybdenum produced in 2008. According to the company, its molybdenum production was expected to increase during the next 3 to 5 years, as new ore zones containing more molybdenum were brought into production at its Andina, Chuquicamata, and El Teniente Mines in Chile (Metal-Pages, 2010b).

Antofagasta plc announced that molybdenum production at its Los Pelambres Mine totaled 7,800 t of molybdenum, unchanged from that of 2008. In May, Antofagasta announced that it had secured a 12-year, $1.05-billion financing deal to develop its Esperanza copper-gold mine in the Antofagasta Region. The company announced that there was potential for molybdenum production in 2015 at a rate of 2,000 t/yr of molybdenum for 10 years. As of yearend, overall construction was approximately 65% complete, with construction of the plant more than 40% complete (Antofagasta plc, 2009).

Molibdenos y Metales S.A. (Molymet) announced that it paid $74 million to acquire a 50% stake in Chinese molybdenum producer Louyang High Tech Molybdenum & Tungsten Material Co. Ltd. Molymet also announced that it was still in the process of seeking permission from Chilean environmental authorities to build a second molybdenum roaster furnace at its plant in Mejillones in northern Chile (Metal-Pages, 2009g). The new plant was expected to have an initial processing capacity of approximately 15,000 t/yr to convert molybdenum concentrate into MoX but had been designed to accommodate expansions of up to four times that capacity, if necessary.

China.— According to the China Nonferrous Metals Industry Association, China produced 93,508 t of molybdenum concentrates in 2009, a 15% increase from that of 2008. In its first year as a net importer of molybdenum, China imported 31,750 t of molybdenum compared with less than 4,535 t of molybdenum in 2008. Exports of molybdenum decreased to an alltime low of 6,800 t of molybdenum compared with 18,140 t in 2008 (Metal-Pages, 2010a). The surge in imports reflected the relatively high production costs of many small and medium-sized molybdenum mines in China.

The Ministry of Land and Resources in China granted Jinduicheng Molybdenum Group Co. Ltd. a mining and exploration license for 30 years at the Donggou molybdenum ore deposit in northern China. The deposit, in the western part of Henan Province, was estimated to have about 650 Mt of crude ore reserves, containing about 690,000 t of molybdenum (Metal-Pages, 2009f).

China Molybdenum Co. Ltd. announced the completion of its smelting plant with a capacity of 40,000 t/yr of molybdenum (Phase I), the Luoyang High Tech 1,500 t/yr molybdenum downstream processing production line at Luoyang High Tech, and the Yongning Gold Company 80,000-t/yr comprehensive smelting plant (Wonderful Sky Financial Group Ltd., 2010).

Mexico.—In October, Creston Moly Corp. (Canada) announced that the initial prefeasibility study was complete, and it was expected to start a first-phase drilling program in January 2010 at its El Creston molybdenum deposit located in the State of Sonora. The resource estimate in the study outlined a proven and probable reserve estimate of 146.7 Mt grading 0.077% molybdenum, with additional measured and indicated resources of 176.8 Mt grading 0.071% molybdenum (Creston Moly Corp., 2009).

Mongolia.—In August, Erdene Resource Development Corp. (Canada) announced a revised resource estimate for its Zuun Mod molybdenum project in southwestern Mongolia. According to the company, the deposit contained measured and indicated resources of 98 Mt at an average grade of 0.062% molybdenum, which at a cutoff grade of 0.05% molybdenum equated to 60,690 t of contained molybdenum. The deposit was considered one of the largest undeveloped copper-molybdenum deposits in Asia. Erdene was expected to continue the paperwork necessary to convert the Zuun Mod exploration license to a mining license, which was expected to be finalized in the second quarter of 2010 (Erdene Resource Devolopment Corp., 2009).

Peru.—The Cerro Verde Mine of FCX is an open pit copper and molybdenum mining complex 32 km southwest of Arequipa. The mine was shut down in the second quarter of 2009 owing to the economic downturn but reopened in September. In 2009, molybdenum production at Cerro Verde was approximately 910 t of molybdenum, compared with 1,360 t of molybdenum in 2008 (Metal-Pages, 2009b).

Outlook

The principal uses for molybdenum were expected to continue to be in chemicals and catalysts and as an additive in steel manufacturing, most importantly alloy and stainless steel. Molybdenum plays a vital role in the energy industry but may become an increasingly essential factor in green technology, where it is used in high-strength steels for automobiles to reduce weight and improve fuel economy. Molybdenum may play a critical role in reducing sulfur in liquid fuels by acting as a cracking agent. Production of ultra-low-sulfur diesel fuels now required in the United States was expected to more than double the amount of molybdenum used in oil refineries. Analysts expected global demand for these types of catalysts to grow by more than 5% annually until 2013. The need for companies to reduce carbon dioxide emissions from coal-fired power stations will require plants to run at higher temperatures, resulting in greater demand for high-end molybdenum-bearing steels.

Historically, molybdenum consumption has shown a strong growth rate, primarily fuelled by rapid increases in China's industrial growth. Molybdenum demand continues to be driven largely by the steel sector. The fall in stainless steel production mainly took place in developed economies. As emerging economies, such as China and India, continue on the path to industrialization, they are expected to need increasing amounts of molybdenum, and this trend is expected to contribute to global demand growth in the coming years.

In 2009, there were significant production cuts at copper and molybdenum producers worldwide, as well as delays and difficulties in sourcing finance, which have delayed many potential projects. High molybdenum prices between 2004 and 2008 encouraged more deposits to be explored and (or) reevaluated; however, with the reduction in molybdenum prices, financing has become much more difficult and expensive for these projects. Many analysts think that by the end of 2010, many operations may begin to resume production; however, potentially very little of the capacity in China will come back online in 2010 if molybdenum prices do not rise to levels that encourage high-cost Chinese operations to restart production. High-cost Chinese operations may continue to act as swing producers when molybdenum prices fluctuate (Virga and Horn, 2009).

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TABLE 1

SALIENT MOLYBDENUM STATISTICS[1]

(Metric tons of contained molybdenum)

	2005	2006	2007	2008	2009
United States:					
Concentrate:					
Production	58,000	59,800	57,000	55,900	47,800
Shipments	57,900	60,100	57,100	57,800	63,700
Reported consumption[2]	46,600	44,400	43,900	44,500 r	W
Imports for consumption	11,900	10,900	12,400	10,200	7,520
Stocks, December 31:					
Concentrate, mine and plant	3,620	2,120	2,630	1,690 r	2,420
Product producers[3]	3,770	3,210	3,140	3,680 r	3,660
Consumers	2,030	1,660	1,870	1,620	1,600
Total	9,420	6,990	7,640	6,990 r	7,670
Primary products:					
Production	78,500	78,000	72,800	72,900 r	59,900
Shipments	46,700	51,000	48,700	51,300 r	43,300
Reported consumption	18,900	19,000	21,000	21,100 r	18,100
World, mine production	186,000	186,000	213,000	218,000	221,000 e

eEstimated. rRevised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Molybdenum concentrates roasted to make molybdenum oxide.

[3] Includes ammonium, calcium, and sodium molybdate; briquets; ferromolybdenum; molybdenum hexacarbonyl; molybdenum metal; molybdenum pentachloride; molybdic acid; pellets; phosphomolybdic disulfide; and technical and purified molybdic oxide.

TABLE 2

PRODUCTION, SHIPMENTS, AND STOCKS OF MOLYBDENUM PRODUCTS IN THE UNITED STATES[1]

(Metric tons of contained Mo)

	Metal powder		Other[2]		Total	
	2008	2009	2008	2009	2008	2009
Received from other producers	3	--	19,000	12,700	19,000	12,700
Gross production during year	5,040	W	67,800	55,000	72,900 r	59,900
Molybdenum products used to make other products	3,400	W	36,300 r	W	39,700 r	W
Net production	1,640	W	31,500 r	32,100	33,200 r	W
Shipments	1,650	W	49,600 r	41,600	51,300 r	43,300
Producer stocks, December 31	285	W	3,390 r	3,610	3,680 r	3,660

r Revised. -- Zero. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes ammonium, calcium, and sodium molybdate; ferromolybdenum; molybdenum disulfide; molybdenum hexacarbonyl; molybdenum metal; molybdenum pentachloride; molybdic acid; molybdic oxides; pellets; and phosphomolybdic acid.

TABLE 3

U.S. REPORTED CONSUMPTION, BY END USES, AND CONSUMER STOCKS OF MOLYBDENUM MATERIALS[1]

(Kilograms of contained Mo)

End use	Molybdic oxides	Ferromolybdenum[2]	Ammonium and sodium molybdate	Molybdenum scrap	Other	Total
2008:						
Steel:						
Carbon	547,000	W	–	–	W	547,000
High-strength low-alloy	806,000	150,000	–	–	136,000	1,090,000
Stainless and heat-resisting	2,200,000	799,000	–	W	114,000	3,110,000
Full alloy	3,290,000	3,640,000	–	–	18,100	6,950,000
Tool	W	W	–	W	–	W
Total	6,840,000	4,590,000	–	W	268,000	11,700,000
Cast irons (gray, malleable, ductile iron)	W	377,000	–	–	51,500	429,000
Superalloys	821,000 r	W	–	W	1,130,000	1,950,000
Alloys (other than steels, cast irons, superalloys):						
Welding materials (structural and hard-facing)	–	W	–	–	728	728
Other alloys	W	84,600	–	–	4,530	89,200
Mill products made from metal powder[3]	40,000	–	–	–	2,230,000	2,270,000
Cemented carbides and related products[4]	–	–	–	–	W	W
Chemical and ceramic uses:						
Pigments	W	–	W	–	–	W
Catalysts	945,000	–	W	–	W	945,000
Other	–	–	–	–	6,930	6,930
Miscellaneous and unspecified uses:						
Lubricants	–	–	–	–	279,000	279,000
Other	825,000 r	508,000	958,000	877,000 r	226,000	3,390,000 r
Grand total	9,470,000 r	5,560,000	958,000	877,000 r	4,200,000	21,100,000 r
Stocks, December 31	338,000	332,000	14,300	35,300	898,000	1,620,000
2009:						
Steel:						
Carbon	427,000	297,000	–	–	W	724,000
High-strength low-alloy	W	117,000	–	–	–	117,000
Stainless and heat-resisting	2,030,000	768,000	–	W	90,900	2,890,000
Full alloy	3,230,000	2,500,000	–	–	W	5,730,000
Tool	W	W	–	W	–	W
Total	5,690,000	3,680,000	–	W	90,900	9,460,000
Cast irons (gray, malleable, ductile iron)	W	314,000	–	–	W	314,000
Superalloys	483,000	15,400	–	W	1,010,000	1,510,000
Alloys (other than steels, cast irons, superalloys):						
Welding materials (structural and hard-facing)	–	36,500	–	–	W	36,500
Other alloys	1,020	38,400	–	–	W	39,400
Mill products made from metal powder[3]	W	–	–	–	W	W
Cemented carbides and related products[4]	–	–	–	–	W	W
Chemical and ceramic uses:						
Pigments	W	–	W	–	–	W
Catalysts	950,000	–	W	–	W	950,000
Other	–	–	–	–	W	W
Miscellaneous and unspecified uses:						
Lubricants	–	–	–	–	271,000	271,000
Other	1,450,000	85,600	W	729,000	2,420,000	4,680,000
Grand total	8,570,000	4,170,000	W	729,000	3,790,000	18,100,000
Stocks, December 31	370,000	325,000	1,960	(5)	(5)	1,600,000

r Revised. W Withheld to avoid disclosing company proprietary data; included with "Other" of the "Miscellaneous and unspecified uses" category. – Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes calcium molybdate.

[3] Includes ingot, wire, rod, and sheet.

[4] Includes construction, mining, oil and gas, and metal working machinery.

[5] Withheld to avoid disclosing company proprietary data; included in "Total."

TABLE 4
U.S. EXPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY[1]

Product and country	HTS[2] code	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)
Oxides and hydroxides, gross weight:[3]	2825.70.0000				
Austria		1,610	$46,600	718	$10,400
Brazil		21	327	318	5,280
Canada		4,800	59,700	1,760	23,500
China		1	12	2,060	29,900
Germany		220	6,100	297	5,050
India		43	659	484	6,730
Japan		4,320	122,000	3,050	46,000
Korea, Republic of		429	13,800	650	9,060
Netherlands		1,230	45,100	526	9,200
United Kingdom		760	28,200	150	2,210
Other (20 countries)		3,230 [r]	106,000 [r]	564	11,900
Total		16,700	428,000	10,600	159,000
Molybdates, all, gross weight:[4]	2841.70.0000				
Belgium		221	2870	157	977
Brazil		40	1360	91	647
Canada		393	7,500	257	2,690
France		78	1,120	194	1,510
Netherlands		317	16,900	411	6,370
Other (6 countries)		493 [r]	17,000 [r]	394	5,180
Total		1,540	46,700	1,500	18,000
Ferromolybdenum, contained weight:[4, 5]	7202.70.0000				
Canada		933	42,900	581	16,100
China		--	--	25	531
India		1	108	65	1,550
Korea, Republic of		14	889	27	583
Mexico		59	3,760	55	1,670
Other (19 countries)		282 [r]	14,700 [r]	71	2,010
Total		1,290	62,400	827	22,400
Molybdenum, other, gross weight:[3, 6]	Various[7]				
Canada		149	7,270	84	3,090
Chile		(8)	30	240	6,740
Germany		171	12,300	137	6,280
Hungary		42	4,480	36	3,180
Israel		118	9,250	63	4,950
Japan		623	69,200	363	31,800
Korea, Republic of		165	21,900	208	23,300
Mexico		79	4,910	73	4,840
Taiwan		94	8,860	76	6,630
United Kingdom		273	16,900	294	6,800
Other (45 countries)		475 [r]	36,500 [r]	211	14,300
Total		2,190	192,000	1,790	112,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule (HTS) of the United States.

[3] Presentation of annual data is based on the quantities (gross weight) of the 10 leading countries in 2009.

[4] Presentation of annual data is based on the quantities (gross weight) of the five leading countries in 2009.

[5] Ferromolybdenum contains about 60 to 65% molybdenum.

[6] Includes powder, unwrought, waste and scrap, wire, wrought, and other.

[7] Includes HTS codes 8102.10.0000, 8102.94.0000, 8102.95.0000, 8102.96.0000, 8102.97.0000, and 8102.99.0000.

[8] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 5

U.S. EXPORTS OF MOLYBDENUM ORE AND CONCENTRATES (INCLUDING ROASTED AND OTHER CONCENTRATES), BY COUNTRY[1, 2]

Country	2008 Quantity (metric tons of contained Mo)	2008 Value (thousands)	2009 Quantity (metric tons of contained Mo)	2009 Value (thousands)
Belgium	6,910	$479,000	7,060	$165,000
Canada	2,030	92,400	1,070	26,600
China	365	6,630	6,680	145,000
Japan	2,220	132,000	912	23,100
Korea, Republic of	694	36,900	884	19,900
Mexico	4,470	60,400	2,870	20,300
Netherlands	9,960	615,000	6,510	153,000
South Africa	11	290	431	6,340
United Kingdom	5,080	352,000	2,440	61,100
Vietnam	341	5,770	229	2,350
Other (19 countries)	634 r	34,600 r	506	7,460
Total	32,700	1,810,000	29,600	631,000

r Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Presentation of annual data is based on the quantities (gross weight) of the 10 leading countries in 2009.

Source: U.S. Census Bureau.

TABLE 6

U.S. EXPORTS OF MOLYBDENUM PRODUCTS[1]

Item	HTS[2] code	2008 Gross weight (metric tons)	2008 Contained Mo (metric tons)	2008 Value (thousands)	2009 Gross weight (metric tons)	2009 Contained Mo (metric tons)	2009 Value (thousands)
Molybdenum ore and concentrates, roasted	2613.10.0000	NA	17,800	$1,140,000	NA	18,000	$393,000
Molybdenum ore and concentrates, other	2613.90.0000	NA	14,900	677,000	NA	11,600	238,000
Molybdenum chemicals:							
Oxides and hydroxides	2825.70.0000	16,700	NA	428,000	10,600	NA	159,000
Molybdates, all	2841.70.0000	1,540	NA	46,700	1,500	NA	18,000
Ferromolybdenum	7202.70.0000	1,840	1,290	62,400	1,200	827	22,400
Molybdenum powders	8102.10.0000	543	NA	34,800	592	NA	21,100
Molybdenum unwrought, bars and rods	8102.94.0000	47	NA	2,910	25	NA	1,300
Molybdenum waste and scrap	8102.97.0000	280	NA	7,360	373	NA	7,010
Molybdenum wire	8102.96.0000	235	NA	23,500	155	NA	12,000
Molybdenum, other	Various[3]	1,080	NA	123,000	641	NA	70,400
Total		22,200	NA	2,540,000	15,100	NA	942,000

NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule (HTS) of the United States.

[3] Includes HTS codes 8102.95.0000 and 8102.99.0000.

Source: U.S. Census Bureau.

TABLE 7

U.S. IMPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY[1]

Product and country	HTS[2] code	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)
Oxides and hydroxides, gross weight:[3]	2825.70.0000				
Chile		143	$6,110	148	$2,360
China		--	--	20	605
Japan		9	54	23	148
Mongolia		126	5,140	18	209
United Kingdom		1	13	(4)	11
Other (4 countries)		56	1,610	--	--
Total		336	12,900	209	3,330
Molybdates, all, contained weight:[3]	Various[5]				
Belgium		11	405	4	587
Canada		4	172	4	116
Chile		110	8,310	434	14,800
China		80	4,270	198	4,270
Japan		7	357	17	663
Other (5 countries)		22	1,770	(4)	32
Total		235	15,300	657	20,500
Molybdenum orange, gross weight:[3]	3206.20.0020				
Canada		324	2,840	227	1,960
Colombia		12	29	12	64
Japan		--	--	1	5
Mexico		31	203	25	134
Netherlands		--	--	4	13
Other (2 countries)		6	40	--	--
Total		373	3,110	269	2,170
Ferromolybdenum, contained weight:[3,6]	7202.70.0000				
Canada		267	19,400	87	2,790
Chile		1,650	119,000	1,730	41,200
China		318	22,100	47	1,230
Japan		5	323	27	962
Russia		--	--	27	853
United Kingdom		--	--	72	2,140
Other (8 countries)		78	5,300	35	922
Total		2,320	166,000	2,030	50,100
Other, gross weight:[7]	Various[8]				
Austria		370	32,200	387	18,800
Canada		8	638	5	526
China		645	47,400	408	15,700
France		(4)	24	19	95
Germany		165	8,600	59	2,530
Hong Kong		17	1,120	9	424
Japan		84	7,940	24	1,460
Russia		27	4,500	12	1,350
United Kingdom		9	741	28	1,140
Uzbekistan		--	--	18	394
Other (16 countries)		97	2,350	1	549
Total		1,420	105,000	970	43,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

TABLE 7—Continued

U.S. IMPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY[1]

[3] Presentation of annual data based on the quantities (gross weight) of the five leading countries in 2009.

[4] Less than ½ unit.

[5] Includes HTS codes 2841.70.1000 and 2841.70.5000.

[6] Ferromolybdenum contains about 60% to 65% molybdenum.

[7] Presentation of annual data based on the quantities (gross weight) of the 10 leading contries in 2009.

[8] Includes HTS codes 8102.10.0000, 8102.94.0000, 8102.95.3000, 8102.95.6000, 8102.96.0000, 8102.97.0000, and 8102.99.0000.

Source: U.S. Census Bureau.

TABLE 8

U.S. IMPORTS OF MOLYBDENUM ORE AND CONCENTRATES (INCLUDING ROASTED AND OTHER CONCENTRATES), BY COUNTRY[1]

	2008		2009	
Country	Quantity (metric tons of contained Mo)	Value (thousands)	Quantity (metric tons of contained Mo)	Value (thousands)
Armenia	124	$7,470	--	--
Canada	2,440	155,000	2,000	$45,700
Chile	2,380	170,000	1,910	54,100
Mexico	3,180	58,200	1,910	17,000
Peru	2,090	120,000	1,690	32,900
Other	17	1,020	--	--
Total	10,200	512,000	7,520	150,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 9

U.S. IMPORTS FOR CONSUMPTION OF MOLYBDENUM PRODUCTS[1]

		2008			2009		
Item	HTS[2] code	Gross weight (metric tons)	Contained Mo (metric tons)	Value (thousands)	Gross weight (metric tons)	Contained Mo (metric tons)	Value (thousands)
Molybdenum ore and concentrates, roasted	2613.10.0000	9,950	6,060	$249,000	7,780	4,800	$94,800
Molybdenum ore and concentrates, other	2613.90.0000	9,140	4,170	263,000	5,590	2,720	54,900
Molybdenum chemicals:							
Oxides and hydroxides	2825.70.0000	335	NA	12,900	209	NA	3,330
Molybdates, all	Various[3]	452	235	15,300	1,170	657	20,500
Molybdenum orange	3206.20.0020	373	NA	3,110	269	NA	2,170
Ferromolybdenum	7202.70.0000	3,470 r	2,320	166,000	3,040	2,030	50,100
Molybdenum powders	8102.10.0000	76	64	7,070	60	52	2,870
Molybdenum unwrought, bars and rods	8102.94.0000	256	255	15,800	107	98	2,880
Molybdenum waste and scrap	8102.97.0000	588	546	30,900	482	473	15,300
Molybdenum wire	8102.96.0000	20	NA	3,060	15	NA	2,120
Molybdenum, other	Various[4]	483	NA	48,700	306	NA	19,800
Total		25,100 r	NA	814,000	19,000	NA	269,000

rRevised. NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule (HTS) of the United States.

[3] Includes HTS codes 2841.70.1000 and 2841.70.5000.

[4] Includes HTS codes 8102.95.3000, 8102.95.6000, and 8102.99.0000.

TABLE 10

MOLYBDENUM-PRODUCING MINES IN THE UNITED STATES IN 2009

State and mine	County	Operator	Source of molybdenum
Arizona:			
Bagdad	Yavapai	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum ore, concentrated and leached.
Mineral Park	Mohave	Mercator Minerals Ltd.	Do.
Sierrita	Pima	Freeport-McMoRan Copper & Gold Inc.	Do.
Colorado, Henderson	Clear Creek	do.	Molybdenum ore, concentrated.
Idaho, Thompson Creek	Custer	Thompson Creek Metals Co. Inc.	Do.
Montana, Continental Pit	Silver Bow	Montana Resources	Copper-molybdenum ore, concentrated and leached.
Nevada, Ashdown	Humboldt	Win-Eldrich Mines Ltd.	Molybdenum ore, concentrated.
New Mexico, Questa	Taos	Chevron Mining	Do.
Utah, Bingham Canyon	Salt Lake	Kennecott Utah Copper Corp.[1]	Copper-molybdenum ore, concentrated and leached.

Do., do. Ditto.

[1] Fully owned subsidiary of Rio Tinto plc.

TABLE 11
MOLYBDENUM: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons of contained molybdenum)

Country[3]	2005	2006	2007	2008	2009[e]
Armenia	3,000 [e]	3,900	4,080	4,250	4,150
Canada	7,667	7,117	6,819	7,724	8,836 [4]
Chile	48,041	43,278	44,912	33,687	34,925 [4]
China[e]	40,000	43,900	66,700	81,000	93,500
Iran[e]	2,476 [4]	2,500	3,600	3,800 [r]	3,700
Kazakhstan	230	250	400	400	380
Kyrgyzstan[e]	250	250	250	250	250
Mexico	4,246	2,519	6,159	7,812	7,800
Mongolia	1,188	1,404	1,978	1,899 [r]	3,000
Peru	17,325	17,209	16,737	16,721	12,295 [4]
Russia[e]	3,000	3,100	3,300	3,600	3,800
United States	58,000	59,800	57,000	55,900	47,800 [4]
Uzbekistan[e]	575	600	600	500	550
Total	186,000	186,000	213,000	218,000	221,000

[e] Estimated. [r] Revised.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 16, 2010.

[3] In addition to the countries listed, North Korea, Romania, and Turkey are thought to produce molybdenum, but output is not reported quantitatively, and available general information is inadequate to make reliable estimates of output levels.

[4] Reported figure.

NICKEL

By Peter H. Kuck

Domestic survey data and tables were prepared by Shonta E. Osborne, statistical assistant, and the world production tables were prepared by Glenn J. Wallace, international data coordinator.

The global recession of 2007–09 led to a dramatic drop in nickel mine production. World mine production slid from an alltime high of 1.67 million metric tons (Mt) of contained nickel in 2007 to 1.40 Mt in 2009. The London Metal Exchange (LME) cash mean for nickel metal began plummeting in the spring of 2008 as the global recession continued. By December 2008, the monthly cash mean had dropped to $9,682 per metric ton—a price level not seen since 2003. At the same time, stocks of nickel metal began to build up in LME-sanctioned warehouses and totaled 78,822 metric tons (t) at the beginning of 2009. The buildup of LME stocks continued during the year and reached an alltime high of 158,424 t at yearend 2009. The monthly cash mean slowly recovered in the second half of 2009 as the economy began to regain strength and, despite the record stock buildup, ended 2009 at $17,061 per metric ton. Increased imports of nickel by Chinese consumers and speculative buying by hedge funds helped support the price recovery.

The recession affected almost every sector of the nickel market owing to the global nature of the economic downturn and financial crisis. Primary nickel use started to recover worldwide as stainless steel production increased during the second half of 2009. Stainless steel continued to account for more than 60% of primary nickel consumption in the world (Nickel Institute, 2011). China was the leading consumer of primary nickel in 2009 and also the leading producer of stainless steel. The European Union (EU) was the second ranked producer of stainless steel. On a global basis, nonferrous alloys accounted for about 12% of primary nickel use, followed by electroplating and other surface finishing, with 11%.

Reported nickel consumption (primary plus secondary) in the United States decreased by 13% compared with that of 2008. Stainless steel comprised only 39% of U.S. primary consumption, a relatively low percentage compared with similar economically developed countries. The low percentage for the United States was a reflection of the large number of specialty metal industries and a readily available supply of stainless steel scrap.

Global nickel consumption increased by an average of 0.7% per year from 2003 to 2009, despite the recession. The gain was largely fueled by strong economic growth in China and increased use of stainless steel in India. The year-on-year growth rate for global stainless steel usage declined by 8.1% (revised) in 2008, and then decreased by an additional 1.6% in 2009 (Vale S.A., 2010b, p. 3–5; International Nickel Study Group, 2011, p. A1–A11).

The global recession dampened acquisitions and mergers of nickel producers in most parts of the world, with some exceptions. In South Africa, Aquarius Platinum Ltd. acquired Ridge Mining plc and subsequently took over management of the Sheba's Ridge project—a nickel and platinum-group elements (PGE) property on the eastern limb of the Bushveld Complex. In Australia, Universal Resources Ltd. and Vulcan Resources Ltd. merged to form Altona Mining Ltd. In early 2010, Altona took over management of the shuttered Hautalampi nickel-copper-cobalt mine along with the Kuhmo and Kylylahti copper-nickel projects—all in eastern Finland. Chinese companies continued to acquire mining interests throughout the world and signed offtake agreements with the owners of nickel mines in Australia, Burma, Canada, Turkey, and Zambia.

Legislation and Government Programs

Government Stimulus Programs.—In February, Congress passed the American Recovery and Reinvestment Act of 2009 (Public Law 111–5). The Act allocated $32.7 billion for upgrading the Nation's energy infrastructure and reducing petroleum consumption in the transportation sector. The $32.7 billion included $3.4 billion for clean coal technology and related fossil energy programs, $2.0 billion for advanced battery manufacturing grants, and $1.64 billion to double the Nation's supply of renewable energy and boost domestic manufacturing of renewable energy generating equipment. The Act approved more than $467 million to accelerate the development and use of geothermal and solar energy throughout the United States and also provided $93 million for wind energy projects (U.S. Department of Energy, 2009a, b). The eligibility dates of special tax credits were extended to encourage construction of advanced power stations designed to capture and transform solar, tidal, or wind energy into electricity and (or) thermal energy (U.S. Internal Revenue Service, 2009). These clean energy programs were expected to spur nickel consumption because design engineers commonly specify austenitic stainless steel, duplex stainless steels, or nickel-based superalloys for critical components in many of the energy-capture or electrical-generating subsystems.

At the State level, a variety of supplemental programs were launched to help accelerate the adoption of clean energy technologies while reducing unemployment. Several State governments already had renewable energy programs in place to encourage contractors to build more energy efficient residential and commercial buildings. At least 32 of the 50 States had some form of solar power rebates, incentives, or tax credits (Valenza, Hahn, and Llorens, 2011). Some States, like Michigan, offered sizable tax credits to companies that agreed to build state-of-the art facilities for manufacturing advanced batteries. Four major battery suppliers decided to participate in the Michigan program and build batteries for motor vehicle propulsion, giving the suppliers a role in the Federal Government's electric vehicle deployment initiative (Dow Chemical Co., The, 2009; Kim, 2009). The four companies were: A123 Systems Inc., Dow Kokam JV, Johnson Controls-Saft Advanced Power Solutions

LLC, and LG Chem Ltd. Several of the newer electric vehicles used proprietary lithium-ion batteries that contained significant amounts of cobalt and nickel.

Federal Power Generation Programs.—The Recovery Act also set aside funds for the development of innovative, low-cost technology that would help existing power generating stations comply with increasingly stringent environmental regulations. For more than a decade, the U.S. Department of Energy (DOE) has supported long-term research designed to reduce greenhouse gas emissions from coal-fired powerplants. At least 80 U.S. coal-fired powerplants have reached or are approaching their life expectancy and cannot be economically retrofitted with existing carbon-capture technology. Austenitic stainless steel and nickel-bearing superalloys would be needed to construct replacement powerplants that operate on natural gas, nuclear energy, or renewable energy. Nickel-base superalloys are expected to play an important role in reducing greenhouse gas emissions from the first generation of advanced coal-fired powerplants. The turbines and boilers of an advanced coal-fired plant would have to operate at significantly higher temperatures and pressures than those at conventional powerplants. The alloys used to fabricate the turbines would have to withstand the rigors of ultra-supercritical (USC) steam. Operation of an advanced USC steam plant should raise the efficiency of the coal combustion process to between 45% and 60% at 650 °C to 760 °C, compared with only 37% for the conventional steam plant. The National Energy Technology Laboratory in Albany, OR, has been evaluating a variety of nickel-base alloys suitable for USC steam turbines, including Inconel 617 (55% nickel), Inconel 718 (52.5% nickel), and Nimonic 90 (55.5% nickel) (Holcomb, 2008).

The use of nickel-bearing steels and superalloys in solar applications is discussed in the Consumption section of this review.

New U.S. Coinage.—In April, the U.S. Mint suspended production of the Jefferson nickel (25% nickel by weight) and the Roosevelt dime (8.33% nickel) for the remainder of 2009. As the economy slowed, Americans began exchanging accumulated coins for paper currency, causing coin stocks to build up far above normal levels at the Federal Reserve Bank. At the same time, the need for coins at local retail banks declined because of fewer transactions. As a result, circulating coin production decreased dramatically to a 45-year low. The Mint's operations in Denver and Philadelphia produced a total of only 86.64 million Jefferson nickels and 146.0 million Roosevelt dimes in 2009, down from 640.56 million nickels and 1,050.5 million dimes in 2008 (U.S. Mint, undated b).

The highly successful 50 State Quarters™ Program ended in December 2008. Because of the popularity and budgetary benefits of the program, the U.S. Congress approved the Mint's request to extend the program and honor the District of Columbia and five U.S. Territories on the 2009 quarters. Again, minting was limited because of the recession. The U.S. Mint produced only 636.2 million of the commemorative quarters in 2009, down from 2,538.8 million in 2008. Each coin weighed 5.67 grams (g) and contained 8.33% nickel; thus 300 metric tons (t) of nickel was used in the six commemoratives released in 2009 (U.S. Mint, undated a, b).

In 2009, the U.S. Mint produced 71.26 million Native American dollar coins. The dollar coin contained 2.0% nickel and weighed 8.1 g. The Mint also produced 352 million Presidential dollar coins in 2009. The composition and weight of the new coin were identical to those of the Native American coin. The combined production of dollar coins in 2009 required 69 t of nickel (U.S. Mint, undated b, c).

Production

***Exploration and Development.*—Alaska.**—Several companies were actively exploring for copper, nickel, and platinum-group elements (PGEs) in southern Alaska. In late 2008, Pacific North West Capital Corp. (PFN) and Stillwater Mining Co. terminated their joint-exploration venture in the Goodnews Bay—Platinum area, 200 kilometers (km) south of Bethel. Since then, PFN has focused part of its exploration efforts on its wholly owned Tonsina property in the Chugach Mountains, northeast of Valdez. At Tonsina, nickel, copper, and PGE sulfide mineralization occurs with chromite in a dunite-rich, serpentinized ultramafic complex (Pacific North West Capital Corp., 2011).

Michigan.—In February, Kennecott Eagle Minerals Co. slowed development of its Eagle copper-nickel mine near Big Bay because of declining nickel prices. Kennecott officials, however, continued to work on permitting and litigation issues tied to the project (Pepin, 2009). In early 2010, the Michigan Department of Environmental Quality (MDEQ) formally approved the permits needed to begin construction of the $300 million underground mine (Michigan Department of Environmental Quality, 2010).

At yearend 2009, Kennecott decided to move ahead with the project. Site preparation work was scheduled to begin in April 2010 (Pepin, 2010). Ore would be trucked from the 49-hectare mine site to a renovated mill at the defunct Humboldt iron ore mine near Champion, where the copper-nickel sulfides would be concentrated. The concentrates would then be railed to Ontario, Canada, for smelting. Kennecott had purchased the Humboldt mill in September 2008 and began cleaning up the site. The mill, idle since the mid-1990s, had fallen into disrepair and would cost about $80 million to renovate (Kennecott Eagle Minerals Co., 2009).

Minnesota.—PolyMet Mining Corp. (Vancouver, British Columbia, Canada) was preparing to mine the NorthMet ore body—a copper-nickel-PGE deposit in the Duluth Complex—pending approval from the State of Minnesota. In November, the Minnesota Department of Natural Resources released the revised draft environmental impact statement (EIS) for public comment 1 year later than originally envisioned. At yearend, the various Federal and State lead agencies were analyzing comments and recommendations from the public so that the environmental review and permitting process could be completed (PolyMet Mining Corp, 2010).

The NorthMet deposit, at the western end of the Duluth Complex, was estimated to have 249 Mt of proven and probable reserves averaging 0.28% copper and 0.08% nickel. Ore from the proposed NorthMet open pit would be shipped to the reconditioned Cliffs Erie mill near Hoyt Lakes, MN, for crushing, grinding, and subsequent flotation. The concentrate would be processed at the Erie site in a new hydrometallurgical plant to produce copper cathode, nickel-cobalt hydroxide, and a precious-metals precipitate. In November, PolyMet agreed to sell $25 million worth of common stock to Glencore International AG (Baar, Switzerland). The $25 million would be used primarily to fund construction of the NorthMet Mine and make modifications to the existing Erie processing facility, which is 10 km away from the mine site (PolyMet Mining Corp., 2009).

Duluth Metals Ltd. (Toronto, Ontario, Canada), Franconia Minerals Corp. (Spokane, WA), and Teck American Inc. (Spokane) continued to actively evaluate other disseminated sulfide deposits in the Duluth Complex (Minnesota Minerals Coordinating Committee, 2011). In October, Duluth Metals released updated resource figures for its Nokomis deposit, northeast of Birch Lake. The new NI 43–101 estimate includes 550 Mt of indicated resources averaging 0.64% copper and 0.20% nickel plus 274 Mt of inferred resources grading 0.63% copper and 0.21% nickel (Duluth Metals Ltd., 2009). At the beginning of 2010, Duluth Metals announced that it had formed a joint venture with Antofagasta Plc (London, United Kingdom) to develop the Nokomis property. Antofagasta, a leading copper producer, would own 40% of the new venture—Twin Metals Minnesota LLC—and would initially provide $130 million to the project. Duluth Metals would own the remaining 60% (Duluth Metals Ltd., 2010, p. 3).

Byproduct Production.—The United States had no active nickel mines in 2009. Except for limited quantities of byproduct nickel that were recovered at some copper and precious metal refineries, imports and recycling met all needs. In 2009, Stillwater Mining Co. (majority owned by OJSC MMC Norilsk Nickel) shipped 388 t of nickel in crystalline sulfate, down from 423 t in 2008. Stillwater mined PGE ore in Montana's Beartooth Mountains. The company's two mills (East Boulder and Nye) together processed 1.07 Mt of ore and subgrade material. Concentrates from the two mills were trucked to the company's smelting and refining complex at Columbus, MT, where a PGE filter cake and byproduct crystalline nickel sulfate containing minor amounts of cobalt were produced. In May, Stillwater completed construction of a second electric smelting furnace at Columbus, which would allow Stillwater to continue processing concentrates during scheduled maintenance shutdowns (Stillwater Mining Co., 2010, p. 6–13, 20–21, 46–47).

Freeport-McMoRan Copper & Gold Inc. (New Orleans, LA) has produced byproduct nickel carbonate at its El Paso, TX, copper refinery since 2004 (Freeport-McMoRan Copper & Gold Inc., 2011, p. 26).

No ferronickel was produced in the United States in 2009 from either domestic or imported ores. Almost all U.S. ferronickel exports were either re-exports or material upgraded for specialty purposes. The steel industry accounted for virtually all the ferronickel consumed in 2009, with more than 98% used in stainless and heat-resistant steels.

Secondary Production.—International Metals Reclamation Co. Inc. (a subsidiary of Vale Inco Ltd.) produced a remelt alloy typically averaging 13% chromium and 12% nickel from recycled materials at Ellwood City, PA. Stainless steel producers used the remelt alloy as a substitute for ferrochromium and ferronickel. In December, Horsehead Holding Corp. (Pittsburgh, PA) purchased the Ellwood City facility from Vale for $34 million. One of Horsehead's subsidiaries is a leading recycler of electric arc furnace (EAF) dust, a secondary material captured in the bag house of the Ellwood City furnace (PRNewswire—FirstCall, 2010).

Gulf Chemical and Metallurgical Corp. (Freeport, TX) [owned by Eramet Group (Paris, France)] was one of a limited number of companies worldwide that processed spent catalysts from petroleum refineries in 2009. The Freeport facility can treat nickel-molybdenum and cobalt-molybdenum hydrotreating catalysts that have been "poisoned" by nickel and vanadium tied up in porphyrins and other organometallic molecules of crude oil. Gulf Chemical first roasts and leaches the catalysts to recover the molybdenum and vanadium. The byproduct nickel-and-alumina residue is then converted to a crude, but marketable nickel-cobalt alloy in a DC EAF (Gulf Chemical and Metallurgical Corp., 2011).

Consumption

U.S. apparent consumption of primary nickel was 93,200 t, or about 7% of world consumption. U.S. industry reported consumption of an additional 79,800 t of nickel in scrap. On the basis of U.S. reported consumption, the share of primary nickel consumed in the production of stainless and alloy steels was 46%, up from 43% in 2008.

The estimated value of apparent primary nickel consumption in the United States was $1.37 billion, down from $2.43 billion in 2008. Apparent primary consumption decreased by 19% from 115,000 t (revised). The sharp decrease in the value of primary consumption resulted from a 31% decrease in the LME cash price, which may have temporarily spurred usage and stocking. Apparent primary consumption plus reported secondary consumption totaled 173,000 t (table 1).

Stainless Steel and Low-Alloy Steels.—In 2009, stainless steel producers accounted for 39% of apparent primary nickel consumption in the United States (table 4) and more than 60% of primary consumption in the world. Production of raw stainless steel and heat-resisting steel in the United States totaled 1.62 Mt in 2009, down by 16% from 1.93 Mt in 2008. Nickel-bearing grades accounted for 1.16 Mt, or 71% of total stainless steel production (American Iron and Steel Institute, 2010a, p. 72–73; b).

The meltshop of North American Stainless (NAS) in Ghent, KY, produced 682,000 t of stainless steel slabs—4% less than that of 2008. NAS was able to maintain its leading position in the flat products market in spite of the global economic crisis (Acerinox, S.A., 2010, p. 24–25, 177–179).

ThyssenKrupp Steel USA, LLC and ThyssenKrupp Stainless USA, LLC have been constructing a $3.7 billion carbon and stainless steel processing facility at Calvert, AL, since late 2007. Total investment was expected to exceed $5.0 billion by 2011. The 1,400-hectare (3,500-acre) facility would include a hot strip mill for processing 3 Mt/yr of carbon steel slab from Brazil and would be capable of producing 4.1 Mt/yr of carbon steel end products. The facility would also have a stainless steel meltshop capable of producing up to 1 Mt/yr of stainless steel slabs. The stainless slabs would be rolled at the new hot strip mill. The ThyssenKrupp project managers chose the greenfield site in Mobile County in part because of its proximity to the Port of Mobile and the Gulf of Mexico. The Brazilian slab would be shipped from Sepetiba Bay, Santa Cruz, in the State of Rio de Janeiro, to Mobile and then transported up the Tombigbee River to the company's river terminal. The first units of the steelmaking complex were expected to come onstream in December 2010. The startup of the stainless steel meltshop was scheduled for December 2012. The meltshop would have a 160-t EAF, a 180-t AOD converter, and a 1,900-millimeter (72-inch) continuous caster (ThyssenKrupp AG, 2010a, b).

Superalloys and Related Nickel-Based Alloys.—Of the primary nickel consumed in the United States, approximately 14% was used to make high-performance superalloys and related nickel-based alloys for the aerospace, electric power, and petrochemical industries. Flat or declining sales to manufacturers of jet aircraft engines and other sectors of the aerospace industry were offset by a sharp rise in sales to the electrical energy and defense sectors.

Since 2007, U.S. aerospace sales have steadily increased in the military aircraft, space, and missile sectors of the industry. Civil aircraft sales, in contrast, were less robust in terms of constant dollars. In 2007, civil aircraft sales plateaued at $42.93 billion, then dropped to $37.95 billion in 2008 but partially recovered to $39.30 billion in 2009. A number of factors affected civil sales, including the global economy, the price of jet fuel, environmental regulations, and the availability of aircraft financing (Aerospace Industries Association, 2010, p. 1–4, 8; Blakey, 2010). Shipments of U.S. manufactured civil jet transport increased from 375 in 2008 to 502 in 2009. The end of the 2008 work stoppage at The Boeing Co. accounted for a large part of the 34% increase (Boeing Company, The, 2010). On a global basis, Airbus and Boeing, the two leading manufacturers of large jet transport, delivered a total of 979 commercial aircraft in 2009, compared with 858 in 2008.

In September 2009, Allegheny Technologies Inc. (ATI) signed a 10-year sourcing agreement with Rolls-Royce plc. (London, United Kingdom). ATI agreed to supply Rolls-Royce with nickel-base superalloys suitable for commercial jet engine applications. ATI has had a similar long-term sourcing agreement with General Electric Aviation since January 2007 (Allegheny Technologies Inc., 2009; 2011, p. F25). Rolls-Royce manufactures gas turbines that power jet aircraft, ships, and electrical generators. Each engine blade of the gas turbine is a single crystal of nickel alloy that has been structurally grown in a vacuum furnace, using a ceramic cast (Rolls-Royce plc, 2011, p. 10–11).

Nickel-Based Batteries and Hybrid Electric Vehicles.—U.S. demand for nickel in rechargeable batteries continued to increase. In 2009, most of the newer hybrid electric vehicles (HEVs) on U.S. highways used nickel-metal hydride (NiMH) batteries to store the energy recovered from the vehicle's regenerative braking circuitry—a system that reduces overall fuel consumption. Ford Motor Co., Honda Motor Co., Ltd., and Toyota Motor Corp. have all relied on NiMH batteries because of their proven durability, stability, and safety. For example, each of the four models of the Toyota Prius 2010 was equipped with a 1.4-kilowatthour (kWh) NiMH battery pack manufactured by Panasonic Electric Vehicle JV (Voelcker, 2010). Cobasys (Orion, MI) was the principal North American manufacturer supplying NiMH battery systems for HEV applications. Ovonic Battery Company, Inc. (Auburn Hills, MI), the inventor and developer of the NiMH battery, had joint ventures, licensing agreements, or other strategic alliances with at least 39 battery manufacturers worldwide.

The battery market remains highly competitive and a variety of lithium ion (Li-ion) and lithium phosphate batteries have begun making inroads against the standard NiMH design. Toyota has been evaluating a Li-ion battery that has a trimetal electrode composed of cobalt, nickel, and manganese. In December, Toyota began manufacturing 500 Prius plug-in hybrids for a long-term test program. The plug-ins reportedly use a first generation Li-ion battery manufactured by Panasonic (Hybrid & Electric Vehicle Progress, 2011, p. 1–3; Ng, 2009).

Nickel Use in the Renewable Energy Industry.—Solar-generated power currently meets less than 1% of U.S. electrical demand but is expected to grow tenfold during the next 10 years (U.S. Energy Information Administration, 2011, table ES1). One type of solar powerplant uses mirrors to concentrate sunlight onto piping filled with molten salt or an equivalent heat transfer fluid. The pipes, tubing, valves, and vessels in the molten salt part of the system are frequently fabricated from S31600 stainless steel to minimize corrosion from the circulating salt (Wong and Coates, 2010).

In 2009, Nevada Solar One, near Boulder City, NV, was the third-ranked concentrating solar powerplant in the world. The 64-MW plant, which uses 18,240 concentrator tubes and covers 160 hectares, has since been overshadowed by larger facilities under construction in California and Spain. In August, eSolar, Inc. commissioned its 5-MW Sierra Sun Tower at Lancaster, CA. The eSolar facility was the only operating solar tower powerplant in the United States. At yearend 2009, Abengoa was planning to build two large solar power stations in the United States—one in Arizona (the 280-MW Solana project) and one in California (the 250-MW Mojave Solar project) (Abengoa Solar, S.A., 2010, p. 13, 22).

Stainless steel is also used to make heat exchangers and hot water tanks for thermo-solar systems. The U.S. Army recently installed a solar-powered, 210-kW (kilowatt) hot water system at its Brooke Medical Center in Fort Sam Houston, TX. The 420-square-meter (m^2), roof-mounted collector system provides hot water at 104 °C for showers and for heating buildings. PepsiCo uses solar energy to generate both steam and electricity at its Frito-Lay food processing facility in Modesto, CA. A collector system of parabolic troughs produces hot, pressurized water, which is then converted to steam. The steam, in turn, heats the cooking oil used to fry the plant's potato and corn chips (Frito-Lay North America, Inc., 2010; Abengoa Solar, S.A., 2011a, b).

Stocks

On January 1, 2009, stocks in LME warehouses worldwide totaled 78,822 t. LME stocks had been slowly building up from an alltime (end-of-month) low of 3,366 t in January 2007. The stock buildup temporarily plateaued during the second quarter of 2009 but began increasing again in August, reaching 158,424 t on December 31. Data collected by the International Nickel Study Group indicated that, at yearend 2009, world nickel producers (excluding those in Austria, China, Macedonia, Serbia, and the Ural region of Russia) had an additional 89,000 t of primary nickel stocks. About 72%, or 64,400 t, of the producer stocks was class I material (refined products with a nickel content of 99% or greater), which included, in order of decreasing quantity, electrolytic cathode, briquets, pellets, powder, and rondelles. The remaining 28% was class II material (products with a nickel content of less than 99%), which included ferronickel, oxide sinter, and East Asian utility nickel. All stocks in LME warehouses were class I (International Nickel Study Group, 2010, p. A1–A2, A7–A8). In comparison, at yearend, U.S. consumer stocks of primary nickel totaled 8,500 t, 7% less than the 9,180 t (revised) in stock at yearend 2008 (tables 1, 5).

Prices

The January 2009 average cash price for 99.8%-pure metal on the LME was $11,302 per metric ton ($5.127 per pound). Nickel prices weakened slightly in the first quarter, bottoming at $9,693 per ton ($4.397 per pound) in March, but then slowly began to rise. The average price for June was $14,956 per ton ($6.784 per pound). Prices continued to rise during the second half of 2009. The monthly average for December was $17,061 per ton ($7.739 per pound), about 1.5 times greater than that of January. The annual average LME price was $14,649 per ton ($6.645 per pound)—31% less than the 2008 average (as posted by the LME and published in Platts Metals Week).

World Review

The world's leading nickel producer was Norilsk (Russia), followed by Vale Inco Ltd. (Brazil and Canada) and the BHP Billiton Group (Australia and United Kingdom). PT Aneka Tambang Tbk. (Indonesia) was in fourth place, producing large tonnages of direct shipping ore for the Chinese nickel pig iron (NPI) industry. Other major producers were Eramet Group (France), Jinchuan Non-ferrous Metals Corp. (JNMC) (China), and Xstrata plc (Switzerland).

In 2009, world use of primary nickel was reported to be 1.24 Mt, down by 11% from the alltime high of 1.40 Mt in 2006 (International Nickel Study Group, 2010, p. A–5). A few nickel producers continued to operate at full capacity, but others cut back production and slowed development or postponed projects because of the decline in nickel prices. A prolonged labor dispute crippled Vale Inco's mining and smelting operations in eastern Canada. Global demand, in contrast, continued to be buoyed by upward spiraling apparent consumption in China, which had risen to 472,000 t in 2009 from 66,800 t in 2000. The Chinese stainless steel industry continued to expand and used a record high 340,000 t of primary nickel in 2009. The Chinese stainless steel industry overtook that of the EU in 2009 to become the leading consumer of primary nickel. The steel industry of the EU consumed 174,000 t of primary nickel in 2009, while the Japanese steel industry was in third place with 79,900 t (Eramet Group, 2010, p. 32–44).

Production of raw stainless steel (excluding production in China, the Commonwealth of Independent States, and Eastern Europe) had been increasing at a compound annual growth rate of 4.8% since 1950. That rate includes the recession period when production decreased from 20.8 Mt in 2007 to 18.9 Mt in 2008 and then to 16.1 Mt in 2009 (Vale S.A., 2010b, p. 4). According to the International Stainless Steel Forum (2011), stainless steel production for the entire world declined to 24.6 Mt in 2009 (preliminary) from 25.9 Mt in 2008 and 27.8 Mt in 2007.

Albania.—Balkan Resources Inc. (Montreal, Quebec, Canada) was managing the Devolli-Kokogllave-Zemblak project near Korca. The 50-50 joint project with European Nickel PLC (London, United Kingdom) was at the prefeasibility stage of development. The joint venture (Devolli Resources, sh.p.k.) planned to develop European Nickel's Devolli deposit and Balkan Resources' Kokogllave and Zemblak deposits as a single mining operation if the project proved economically feasible. The three licensed areas cover a total of 51 square kilometers and contain at least 102 Mt of lateritic ore grading 1.2% nickel. The Devolli deposit has two components—the Kapshtica West area, which contains 13.7 Mt of inferred resources grading 1.21% nickel, and the Verniku area, with 21.9 Mt grading 1.19% nickel (Balkan Resources Inc., 2010; European Nickel PLC, 2010) (table 13).

Australia.—Australia was the third ranked nickel-producing country in the world. Seven companies in Western Australia reported producing salable nickel in 2009. One other company, plus two of the seven, trucked sulfide ore to BHP Billiton's concentrator at Kambalda for further processing [Department of Mines and Petroleum (Western Australia), 2010, p. 38–40]. In February, OZ Minerals Ltd. (Melbourne, Victoria) placed its Avebury Mine in Tasmania on care-and-maintenance status because of deteriorating nickel prices. Avebury remained closed for the remainder of 2009.

Laterite Operations.—In December 2008, BHP Billiton suspended production at its newly constructed Ravensthorpe mining and processing complex, northwest of Esperance in Western Australia. The $2.09 billion complex was designed to recover up to 50,000 metric tons per year (t/yr) of contained nickel and 1,400 t/yr of cobalt in the form of a nickel-cobalt hydroxide precipitate. The mixed hydroxide precipitate was initially sent to the company's Yabulu refinery in Queensland for further processing, but the shipments of precipitate were halted because of concerns about profitability. The Yabulu refinery continued to process laterite ores purchased from third party mines in Indonesia, New Caledonia, and the Philippines as its main feedstocks. In July, BHP Billiton sold the Yabulu refinery to an Australian entrepreneur for an undisclosed amount of money (Keenan, 2009). In 2009, the Yabulu refinery produced about 35,000 t of nickel in compacts (a product similar to rondelles) averaging 98.5% nickel or greater (BHP Billiton, 2009, p. 34–36, 53, 108, 113, 165).

In the second half of 2009, First Quantum Minerals Ltd. approached BHP Billiton and offered to buy the Ravensthorpe complex for $340 million. Engineers for First Quantum thought that the plant was capable of producing between

28,000 and 39,000 t/yr of nickel metal if $150 million worth of modifications were made to the front end of the complex. BHP Billiton agreed to sell and the transaction was closed in February 2010. Recommissioning was scheduled for late 2011. The three laterite deposits at Ravensthorpe—Halleys, Hale-Bopp, and Shoemaker-Levy—have 235 Mt of combined reserves grading 0.67% nickel (First Quantum Minerals Ltd., 2009; 2010a; b, p. 9–12).

The Murrin Murrin joint venture near Leonora used sulfuric acid to leach nickel and cobalt from lateritic ores in high temperature, high-pressure autoclaves. The laterite mining and processing operation produced 32,977 t of nickel, up by 8% from 30,514 t produced in 2008. Murrin Murrin was jointly owned by Minara Resources Ltd. (60% interest) and Glenmurrin Pty. Ltd. (a subsidiary of Glencore) (40%). Nickel production was higher in 2009 than in 2008, but ore grades were slightly lower. In 2009, Murrin Murrin mined 1.64 Mt (dry) of ore grading 1.29% nickel and 0.104% cobalt. Minara was in the process of installing a sixth reduction autoclave at the Murrin Murrin refinery. A new $1.7 million autoclave was scheduled to be commissioned in late 2010 (Minara Resources Ltd., 2010, p. 6, 16, 19).

Sulfide Operations.—*Tasmania.*—In February, OZ Minerals stopped hauling ore and put its new Avebury Mine near Zeehan on indefinite care-and-maintenance status. In June, China Minmetals Corp. (Beijing, China) acquired the mine and mill when Minmetals bought OZ Minerals for $1.39 billion. A new Australian company, Minerals and Metals Group Ltd., was created to manage all of the assets of OZ Minerals, including Avebury. The Avebury mill, commissioned in August 2008, was designed to produce about 8,500 t/yr of contained nickel in concentrate (OZ Minerals Ltd., 2008; China Minmetals Corp., 2009).

Western Australia.—In 2009, BHP Billiton's Nickel West produced 66,300 t of metal briquettes and powder at Kwinana from concentrates smelted at Kalgoorlie. Kwinana also produced several intermediate products, including cobalt-nickel sulfide, copper sulfide, and ammonium sulfate. Nickel West was the third ranked producer of nickel-in-concentrate in the world.

The Kalgoorlie smelter produced about 28,200 t of nickel in finished matte for export. The matte typically contains 68% nickel. About one-third of the concentrate came from the Mount Keith Mine in the Northern Goldfields region. The remaining two-thirds came from Leinster and third party mines at Kambalda. Nickel West continued to expand its Mount Keith operation and was reevaluating the undeveloped Yakabindie deposit, 25 km south of Mount Keith. About 15% of the nickel ores at Mount Keith contain excessive levels of talc. In September, contractors began constructing a magnesium oxide flotation circuit at Mount Keith designed to separate the talc from the pentlandite concentrate, producing a marketable coproduct (BHP Billiton, 2010, p. 34–36).

In 2009, Norilsk Nickel International produced 1,223 t of nickel in concentrates at its Lake Johnston sulfide flotation plant. The concentrates were produced from ores mined at its nearby Emily Ann and Maggie Hays underground workings or from ores supplied on a toll basis by Western Areas NL. Norilsk Nickel International also operated the Black Swan-Silver Swan mining complex and the Waterloo underground mine. In late 2008, Norilsk Nickel International had placed its Silver Swan and Waterloo Mines on care-and-maintenance status. In February 2009, Norilsk's Australian subsidiary also placed its Black Swan and Lake Johnson Mines on care-and-maintenance status. All four mines were still closed at the beginning of 2010 (OJSC MMC Norilsk Nickel, 2010, p. 52–55, 62).

Western Areas NL commissioned its high-grade Flying Fox Mine at Forrestania in late 2008 and was constructing a second high-grade mine, Spotted Quoll, in the district. The two mines reportedly have a combined 3.94 Mt of resources grading 5.3% nickel. The Tim King open pit at Spotted Quoll was scheduled to begin production in June 2010. Development of the underground portion of Spotted Quoll was scheduled to begin in March 2011 (Department of Mines and Petroleum [Western Australia], 2010, p. 38; Western Areas NL, 2010, p. 4–16, 19).

In November 2008, production was suspended at more than eight other Western Australian mines because of deteriorating nickel prices. Some of these mines resumed production in fiscal year 2009–10. This second set of active mines included the Carnilya Hill, Mariners, McMahon, Miitel, and Otter Juan Mines (Mincor Resources NL), the Cosmos, Tapinos, and Sinclair Mines (Xstrata Nickel Australasia Pty. Ltd.), the Lanfranchi and Savannah Mines (Panoramic Resources Ltd.), and the Lounge Lizard Mine (Kagara Ltd.) (Department of Mines and Petroleum [Western Australia], 2010, p. 38–40).

Brazil.—Three companies mined nickel ore in Brazil in 2009—Anglo American Brasil Ltda., Cia. de Nickel do Brasil, and Grupo Votorantim. Four major mining and (or) metallurgical processing complexes were under construction—the Barro Alto ferronickel smelter and refinery in Goias State (Anglo American plc), the Niquelandia ferronickel smelter in Goias State (Votorantim Metais), the Onca Puma mining and ferronickel complex in Para State (Vale Inco Ltd.), and the Santa Rita Mine in Bahia State (Mirabela Nickel Ltd.).

Votorantim Metais was the leading producer of electrolytic nickel in Latin America and operated a nickel-cobalt refinery in Sao Miguel Paulista, Sao Paulo State, capable of producing 23,000 t/yr of electrolytic nickel and 1,420 t/yr of electrolytic cobalt. The Sao Miguel Paulista refinery used intermediate nickel carbonate from the company's operation in Niquelandia for feed. The electrolytic nickel was 99.9% pure and was registered on the LME. Votorantim's sulfide smelter at Fortaleza de Minas, Minas Gerais State, produced an estimated 9,500 t of nickel in matte in 2009, primarily for export to Finland, up from 8,328 t (revised) in 2008 (Da Silva, 2010). The matte typically assays 50% to 55% nickel, 7% to 12% copper, and 0.14% to 1% cobalt (Votorantim Metais, 2008).

In August, Mirabela Nickel Ltd. (Perth, Australia) began mining at its Santa Rita project near Ipiau, Bahia. The crushing, grinding, and concentrating complex was commissioned in October. When rampup is completed in 2010, Santa Rita was projected to produce 27,000 t/yr of nickel in sulfide concentrate. Mirabela expected to ship 50% of the concentrate produced at Santa Rita to Norilsk Nickel's Harjavalta smelter in Finland for further processing. The remaining 50% would be trucked 1,350 km to the Fortaleza smelter in Minas Gerais. Santa Rita reportedly had 15 Mt of proven reserves averaging 0.65%

nickel and 106 Mt of probable reserves grading 0.59% nickel (Mirabela Nickel Ltd., 2009, p. 2–8, 12–13).

Burma.—China Nonferrous Metal Mining Group (CNMC) was in charge of developing the Tagaung Taung (Dagongshan) laterite mine in Thabeikkyn township, Mandalay Division. CNMC began a feasibility study of the $800 million project in mid-2004 and was given approval to proceed in 2007 by the National Development & Reform Commission of China. The Government of Myanmar was a partner in the project and has issued the required investment and mining permits. Tagaung Taung is a 12-km by 18-km massif that rises 750 meters (m) above the lower terraces of the Ayeyawaddy River. The massif is composed largely of serpentinized harzburgite (orthopyroxene peridotite) and dunite (olivine peridotite). The laterite deposit reportedly has 70 Mt of ore grading 2.0% nickel. Construction of the mining and smelting complex began in December. The mine was scheduled to be commissioned in mid-2011. The adjacent smelter would be capable of producing 22,000 t/yr of nickel in ferronickel averaging 26% nickel. All the ferronickel would be shipped to Chinese stainless steel producers. Power for the smelter would come from the Shweli Hydel project in Nam Khan Township, Northern Shan State (China Business News, 2010; Government of Myanmar, Ministry of Mining, 2011).

Canada.—**Manitoba.**—Vale Inco's operations at Thompson produced 28,800 t of refined nickel in 2009 from ores extracted from the Birchtree and Thompson Mines. The Thompson Mine extracted 1.27 Mt of ore grading 1.98% nickel, while the Birchtree Mine extracted 769,000 t grading 1.48% nickel (Vale S.A., 2010a, p. 32–36).

In February, Crowflight Minerals Inc. shipped the first nickel concentrates from its new Bucko Lake Mine near Wabowden. By June, Bucko Lake was operating at greater than 60% of mill capacity. In November, Crowflight suspended all mining and milling operations for 3 months so that key improvements and upgrades could be made to the operation. The mine produced 627 t of nickel in concentrate in 2009 and resumed milling in March 2010. All of the concentrate was processed at Xstrata's Falconbridge smelting complex in Ontario (Crowflight Minerals Inc., 2010, p. 1–9).

Newfoundland and Labrador.—The Ovoid Mine at Vale Inco's Voisey's Bay operation extracted 990,000 t of ore grading 3.20% nickel and 2.57% copper. The mined tonnage yielded 39,700 t of finished nickel, down from a record 77,500 t in 2008 (Vale S.A., 2010a, p. 34–35). A prolonged labor dispute that began in August and continued into 2010 was responsible for the 49% decrease in production of concentrate. Vale Inco shipped the high-grade nickel concentrate produced at Voisey's Bay to Sudbury and Thompson for smelting and downstream processing.

Ontario.—Sudbury has been the largest nickel-producing district in Canada since the discovery of the first ore body in 1883. Vale Inco's Ontario Division was the leading nickel producer despite a prolonged strike that began in July. The division produced only 43,600 t of finished nickel in 2009 on an ore-source basis, compared with 85,300 t in 2008 and 70,700 t in 2007. The division had six mines operating in 2009, the largest being the Stobie in terms of gross tonnage, followed by the Coleman. Part of the refined nickel was recovered from intermediate nickel oxide at the division's Clydach refinery in the United Kingdom (Vale S.A., 2010a, p. 32–36).

Vale Inco continued to develop its new $450 million Totten Mine despite the ongoing strike. The new mine could be operational by the end of 2011 (Tollinsky, 2009).

Xstrata, Sudbury's other principal producer, mined 716,000 t of ore with an average grade of 1.31% nickel and 2.08% copper (Xstrata plc, 2010b, p. 7). Xstrata's smelter at Falconbridge produced 65,889 t of nickel in matte, which was shipped to the company's Nikkelverk operations in Norway for refining. Xstrata's new Nickel Rim South Mine, which opened in 2009, offset declining production from the Craig, Fraser, and Thayer-Lindsley operations. Xstrata halted all mining operations at Thayer-Lindsley in January 2009 because the mine was an older, higher cost operation in a depressed nickel market and was approaching the end of its productive life (Xstrata plc, 2008a, b).

In late 2008, FNX Mining Co. Inc. began cutting back nickel mining operations at the Levack Complex on the north rim of the Sudbury Basin. Because of the decline in nickel prices, the company decided that the contact nickel deposits at the Levack Mine could no longer be economically mined. At yearend 2008, FNX suspended nickel ore production at the adjacent McCreedy West Mine. In 2009, FNX focused its efforts on mining copper-precious metal ores from the Rob's deposit at Levack, the 700 and PM deposits at McCreedy West, and the 2000 deposit at the Podolsky Mine. Because of this shift in strategy, FNX's payable nickel production in 2009 was only 1,990 t, compared with 5,940 t in 2008 (FNX Mining Co. Inc., 2010, p. 7–15).

Xstrata mined 209,000 t of ore averaging 1.02% nickel at its Montcalm Mine near Timmins and treated 226,000 t of ore at the company's Kidd mill, where 1,961 t of nickel in concentrate was recovered (Xstrata plc, 2010b, p. 7).

In June 2009, Noront Resources Ltd. (Toronto) discovered additional nickel-copper-PGE mineralization at its Eagle One deposit in the McFaulds Lake District. The district is located in the James Bay Lowlands, in the far northwestern corner of Ontario, where infrastructure is minimal. The original discovery of copper-nickel sulfides at the Eagle One site in August 2007 accelerated an exploration rush north of the Albany River that led to the identification of two massive chromite zones and a variety of nonferrous metal targets in and around a large ultramafic intrusion—the Ring of Fire (53° N latitude, 86° W longitude). At yearend 2009, Eagle One (later renamed Eagle's Nest) had 6.9 Mt of indicated resources averaging 2.04% nickel and 0.95% copper (Noront Resources Ltd., 2010; 2011; Schwartz, 2010).

Quebec.—Xstrata's Raglan Mine in northern Quebec produced 29,262 t of nickel in concentrate, which was 13% greater than the 25,873 t recovered in 2008 (Xstrata plc, 2010b, p. 7).

China.—According to the China Nonferrous Metals Industry Association, China produced 165,000 t of electrolytic nickel in 2009, up 28% from 129,000 t in 2008. Electrolytic nickel from Jinchuan Non-ferrous Metals Corp. (JNMC) accounted for 131,000 t, or 79% of the national total. JNMC operated the Yongchang mining complex at Jinchang in Gansu Province

(Copper & Nickel Monthly, 2010, p. 22–24). Jilin Jien Nickel Industry Co., Ltd. produced about 8,500 t of nickel in salts, metal, and matte in 2009. Jilin Jien had two operations in Jilin Province plus the Siziwngqi Mine in Inner Mongolia. Xinjiang Xinxin Mining Industry Co., Ltd. and at least four other companies also produced primary nickel in China during 2009.

Chinese consumption of primary forms of nickel continued to escalate and was estimated to have reached 472,000 t in 2009, which was 35% greater than that of 2008 (Eramet Group, 2010, p. 43). The Chinese stainless steel industry accounted for 72% of the country's primary nickel consumption. China was the world's leading stainless-steel-producing country in 2009, with a crude stainless steel output of 9.55 Mt, 35% greater than the 7.09 Mt in 2008. Chinese production of stainless steel resumed its upward growth in 2009 after registering a decline the previous year for the first time in more than a decade. Chinese production of stainless steel has been growing at an average annual rate of 37% since 1999. Four companies—the Baosteel Group, Lianzhong Iron and Steel Co. (LISCO), Taiyuan Iron & Steel (Group) Co., Ltd. (TISCO), and Zhangjiagang Pohang Stainless Steel Co. Ltd. (ZPSS)—accounted for about 60% of the country's stainless steel meltshop production (Vale S.A., 2010b, p. 4, 16).

Since 2001, China had consumed more stainless steel annually than any other country. In 2009, China consumed 8.54 Mt of stainless steel, about 41% of the world total and a tonnage larger than the total consumption of Japan, the United States, and Western Europe combined. Chinese imports of stainless steel had been declining since 2006 but rose slightly in 2009 to 1.29 Mt. Exports slipped to 0.897 Mt in 2008 and declined even further in 2009 to 0.660 Mt (Vale S.A., 2010b, p. 4, 6, 12, 16, A37–A38).

China has a large electroplating industry and a number of rechargeable battery manufacturers that use nickel. China's plating industry accounted for about 13% of the country's primary nickel demand in 2009, while battery manufacturers consumed about 5% (Copper & Nickel Monthly, 2010, p. 9–13, 33–35; Eramet Group, 2010, p. 43).

In 2008, China's stainless steel producers used relatively inexpensive nickeliferous pig iron (NPI), typically grading 4% to 6% nickel, as a substitute for ferronickel and scrap. Most NPI producers halted production in 2009 because of declining demand. The market price for NPI was very close to production costs. A few companies in Jiangsu and Shandong Provinces, however, remained open because of low transport costs and their proximity to key seaports. Three NPI operations in Jiangsu Province reported sales in 2009: Boruite (a 200-t/yr blast furnace operation producing 5% nickel NPI), Huaibei (a 2,160-t/yr EAF operation producing 14.5% nickel NPI), and Jinxiang (a 960-t/yr EAF operation producing 12% nickel NPI) (Copper & Nickel Monthly, 2010, p. 22–24).

Finland.—Talvivaara Mining Co. Plc (Espoo) began heap bioleaching on a commercial scale in July 2008. The company produced its first metal sulfide precipitates from the leach solution in October 2008 and delivered its first shipment of mixed nickel-cobalt sulfide to Norilsk Nickel Harjavalta Oy in February 2009 (Talvivaara Mining Co. Plc., 2009, p. 24–27).

Indonesia.—PT Aneka Tambang Tbk. (Antam) cut back production of saprolite ore when purchases from NPI producers in China began to decline. The state-owned company mined 5.85 Mt (wet) of various laterite ores, down from the alltime high of 7.11 Mt in 2007. About 83% of the production was direct shipping ore for export—primarily to China, Eastern Europe, and Japan. Antam produced only 12,550 t of nickel in ferronickel, down from 17,566 t in 2008. Antam's three smelters at Pomalaa had a combined capacity of 26,000 t/yr of nickel in ferronickel (in the form of ingot and shot averaging 19% to 21% nickel) (PT Aneka Tambang Tbk., 2010, p. 54–55, 76–77).

PT Inco mined 3.60 Mt of ore averaging 2.02% nickel from its Pomalaa and Sorowako concessions on Sulawesi. The production figure represents the amount of product delivered to the company's smelter from its adjoining dryer kilns. The smelter produced 68,800 t of nickel in matte for export to Japan, up from 68,300 t in 2008. Vale has a 59% interest in PT Inco (Vale S.A., 2010a, p. 33–35).

Korea, Republic of.—In late 2008, Société du Nickel de Nouvelle-Calédonie et Corée (SNNC) commissioned a ferronickel plant at Gwangyang, adjacent to the stainless steel operations of Pohang Iron and Steel Co. Ltd. (POSCO). By October 2009, the plant was operating close to design capacity—30,000 t/yr of nickel in ferronickel shot averaging 17% to 18% nickel. SNNC is a joint venture of Société Minière du Sud Pacifique (SMSP) (51%) and POSCO (49%).

Madagascar.—The Ambatovy project passed a number of key milestones in 2009. At yearend, engineering was 98% complete and construction was almost two-thirds complete. The Ambatovy project is built around the Sherritt hydrometallurgical process for recovering nickel and cobalt from lateritic ores. The Ambatovy ore would be piped 220 km from the mining area to the processing plant as a water-based slurry. The ore would be treated with sulfuric acid in autoclaves operating at elevated temperatures and pressures to dissolve the nickel and cobalt. The metal-rich solution is recovered by countercurrent decantation washing and treated to produce a mixed sulfide intermediate. The mixed sulfide intermediate will be dissolved, producing a concentrated solution of nickel and cobalt, which are separated by solvent extraction (Sherritt International Corp., 2010 a, p. 11–16; b, p. 2.)

New Caledonia.—Société Le Nickel (a subsidiary of Eramet) produced 38,229 t of nickel in ferronickel at its Doniambo smelter. The smelter also produced 13,902 t of nickel in matte, which was shipped to Eramet's Sandouville refinery in France for conversion into LME-grade metal and chemicals (International Nickel Study Group, 2010).

In 2009, Vale Inco Nouvelle-Calédonie SAS (formerly named Goro Nickel SAS) began conducting performance tests in stages at its new Grand Sud hydrometallurgical plant. Performance testing of the autoclaves was scheduled to begin in February 2010. The $4.3 billion mining and processing complex was expected to have a production capacity of 60,000 t/yr of nickel in intermediate product (Vale S.A., 2010a, p. 32–34).

SMSP and its joint-venture partner, Xstrata, were developing the saprolitic portion of the Koniambo laterite deposit near Kone in the Northern Province. The metallurgical plant was being constructed in modules in China, with the first module scheduled to arrive in the summer of 2010. The plant would be capable of producing 60,000 t/yr of nickel in ferronickel (Xstrata plc, 2010a, p. 14, 50, 82).

Russia.—About 82% of Norilsk's sales of marketable nickel came from its Russian operations. The other 18% was generated by the company's holdings in Australia, Botswana, Finland, and South Africa. Norilsk's operations on the Kola and Taimyr Peninsulas had a combined output of 232,813 t of nickel metal—about 89% of Russia's primary nickel output for the year. Norilsk's two Arctic subsidiaries exported almost all of their nickel production; only about 10,000 t, or less than 5%, was sold to Russian consumers (OJSC MMC Norilsk Nickel, 2010, p. 52–62).

OAO Mechel (Moscow) owned and operated the Southern Urals ferronickel smelter in Orenburg Oblast and the two laterite mines—Buruktal and Sakahara—that supplied the operation. Mechel produced 15,565 t of nickel in low-iron ferronickel in 2009. The bulk of the production was shipped to the ports of Kaliningrad and St. Petersburg for export to the EU. The remainder was used to make stainless steel at Mechel's stainless steel plant at Chelyabinsk (OAO Mechel, 2010, p. 99–107).

Outlook

U.S. nickel consumers will probably be dependent on foreign sources of refined metal and ferronickel for at least the next 25 years. The ongoing expansion of nickel laterite mining operations in Brazil, Indonesia, New Caledonia, and other tropical countries will help meet the increasing demand for nickel worldwide. The nickel output from Vale's state-of-the-art leach facility at Goro in New Caledonia is expected to satisfy the near-term rise in global demand projected after 2010. Long-range forecasts of growing usage in Asia have encouraged parastatal companies in China to fund the development of greenfield laterite mines in Burma, Papua New Guinea, and Turkey. European and North American companies were seriously considering funding large-scale laterite projects in Cameroon, Guatemala, and the Philippines. Ongoing political unrest in Côte d'Ivoire, however, discouraged development of the Biankouma and Sipilou deposits.

Sulfide mines approaching the end of their productive lives because of dwindling reserves and high operating costs continue to be replaced. Discoveries of high-grade sulfide deposits are becoming less frequent, harder to find, located farther from shipping routes, and more costly to finance. Advances in extraction technology may offer a solution. As a result of advances in bioengineering, large-tonnage, low-grade polymetallic sulfide ore deposits like those at Sotkamo, Finland, previously passed over, are now amenable to heap bioleaching.

Producers and consumers of nickel are optimistic about the long-term outlook for the metal. Unprecedented urbanization, especially in Brazil, China, India, Russia, and other emerging nations, should help spur nickel consumption, particularly in industries that manufacture chemicals, cutlery, food service equipment, home appliances, and kitchen utensils.

A number of environmental scientists and climatologists have expressed concerns about global warming and associated climate changes. Some researchers have stated that carbon emissions must be reduced by approximately 80% by the year 2050 to avoid a 2 °C increase in global warming. Many older coal-fired powerplants—worldwide—would have to be retired to accomplish this reduction. Global demand for electricity, however, continues to increase. To meet demand, the power industry will have to build many more generating stations—stations that either operate on renewable energy (geothermal, solar, or wind) or are designed to better utilize uranium or thorium (safer, fourth generation nuclear reactors) (Kirsch, 2009). Development of advanced USC coal-fired plants would also help. All of this construction would require large tonnages of nickel-bearing stainless steel and superalloys (Wong and Coates, 2010).

Consumption of nickel in the transportation sector is expected to increase, but at a slower rate than in the past. European and North American usage of nickel- and cobalt-base superalloys was expected to escalate between 2013 and 2017, largely because of increasing demand for new jet aircraft. The Boeing Co. and Airbus S.A.S. both have a large backlog of jet-aircraft orders (Boeing Co., The, 2010). Some energy analysts have predicted that world crude oil production may peak a decade earlier than predicted—perhaps as soon as 2014 (Nashawi, Malallah, and Al-Bisharah, 2010). Significantly higher gasoline prices could encourage the replacement of conventional automobile steel frames with lighter ones fabricated from stronger stainless steel. The burgeoning development of renewable energy sources was expected to accelerate research on cost-effective, more advanced batteries, especially for automobiles and remote power stations.

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TABLE 1

SALIENT NICKEL STATISTICS[1]

(Metric tons of contained nickel unless otherwise specified)

	2005	2006	2007	2008	2009
United States:					
Secondary recovery from purchased scrap:					
From ferrous scrap	89,700	94,000	89,700	76,100	72,000
From nonferrous scrap	8,820	9,360 r	9,220 r	9,140 r	7,720
Shipments of purchased scrap[2]	139,000	142,000	186,000	160,000	152,000
Exports:					
Primary	7,630	8,050	13,100	11,600	7,030
Secondary	55,600 r	59,300	103,000	94,600	90,000
Imports for consumption:					
Primary	143,000	153,000	125,000	129,000	99,900
Secondary	15,500	20,300	16,200	20,100 r	17,700
Consumption:					
Reported:					
Primary	100,000	101,000 r	101,000	102,000	83,600
Secondary, purchased scrap[3]	98,500	103,000	98,900	85,200	79,800
Total	199,000	205,000 r	200,000	187,000 r	163,000
Apparent:					
Primary	135,000	144,000 r	112,000	115,000	93,200
Secondary	57,800	64,300	6,950 r, 4	12,400 r	8,260
Total	193,000	208,000	119,000	128,000	101,000
Apparent primary plus reported secondary	233,000 r	247,000	211,000	200,000	173,000
Stocks, yearend:					
Producers and traders	5,940	6,450	5,690	5,860	6,150
Consumer, primary	6,970	7,670 r	7,450 r	9,180 r	8,500
Consumer, secondary	6,210 r	6,420 r	11,700	9,990 r	9,260
Total	19,100 r	20,500	24,800	25,000	23,900
Price, cash, London Metal Exchange:					
Average annual dollars per metric ton	14,738	24,244	37,216	21,104	14,649
Average annual dollars per pound	6.685	10.997	16.881	9.572	6.645
Price, 18/8 stainless steel scrap, 304, gross weight:[5]					
Average annual dollars per metric ton	1,445	2,057	2,952	2,361	1,462
Average annual dollars per long ton	1,468	2,090	2,999	2,399	1,486
World, mine production	1,460,000 r	1,570,000	1,670,000 r	1,560,000 r	1,400,000

r Revised.

[1] Data are rounded to no more than three significant digits; except prices; may not add to totals shown.

[2] Defined as scrap receipts less shipments by consumers plus exports minus imports plus adjustments for consumer stock changes.

[3] More clearly delineates the amount consumed than does apparent consumption.

[4] The significant decrease in secondary apparent consumption reflects increased exports of scrap to China and Taiwan.

[5] Derived from the average of the Friday consumer buying price range for 18% chromium, 8% nickel scrap in bundles, solids, and clips, Pittsburgh, PA, in American Metal Market (AMM). On November 1, 2006, AMM began reporting prices for Type 316 solids & clips and has changed its listing for 18/8 bundles, solids & clips to Type 304 solids & clips.

TABLE 2
NICKEL RECOVERED FROM PURCHASED SCRAP IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY[1]

(Metric tons of contained nickel)

	2008	2009
Kind of scrap:		
Aluminum-base[2]	2,080 r	1,580
Copper-base	1,610	1,160
Ferrous-base[3]	76,100	72,000
Nickel-base	5,460 r	4,990
Total	85,200	79,800
Form of recovery:		
Aluminum-base alloys	2,080 r	1,580
Copper-base alloys	2,560 r	1,780
Ferrous alloys	76,100	72,100
Nickel-base alloys	4,470	4,280
Total	85,200	79,800

rRevised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Primarily borings and turnings of wrought alloys, such as 2218, 2618, 4032, and 8280, or special casting alloys, such as 203.0.

[3] Primarily stainless and alloy steel scrap consumed at steel mills and foundries.

TABLE 3
REPORTED U.S. CONSUMPTION OF NICKEL, BY FORM[1]

(Metric tons of contained nickel)

Form	2008	2009
Primary:		
Metal	88,600	72,500
Ferronickel	11,200 r	9,130
Oxide and oxide sinter[2]	216 r	148
Chemicals	783 r	864
Other	1,360	935
Total	102,000	83,600
Secondary, scrap[3]	85,200	79,800
Grand total	187,000 r	163,000

rRevised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes chemical-grade oxide.

[3] Based on gross weight of purchased scrap consumed and estimated average nickel content.

TABLE 4
U.S. CONSUMPTION OF NICKEL, BY USE[1]

(Metric tons of contained nickel)

Use	2009								Grand total in 2008
	Metal	Ferronickel	Oxide and oxide sinter	Chemicals	Other forms	Total primary	Secondary (scrap)	Grand total	
Consumption reported:									
Cast irons[2]	56	--	--	--	W	56	149	205	232 r
Chemicals and chemical uses	1,090	--	--	653	--	1,740	--	1,740	844
Electric, magnet, expansion alloys	140	--	--	--	--	140	1	141	189 r
Electroplating, sales to platers	11,500	--	--	44	W	11,500	--	11,500	9,560 r
Nickel-copper and copper-nickel alloys	689	--	W	--	14	703	1,890	2,600	4,930 r
Other nickel and nickel alloys	16,000	W	W	--	52	16,100	3,810	19,900	22,200 r
Steel:									
Stainless and heat resistant	24,200	8,470	W	--	306	32,900	70,800	104,000	110,400 r
Alloys, excludes stainless	5,280	400	W	--	W	5,680	619	6,300	8,680 r
Superalloys	11,500	W	--	W	311	11,800	236	12,000	22,900 r
Other[3]	2,060	260	148	167	252	2,890	2,290	5,180	7,400 r
Total	72,500	9,130	148	864	935	83,600	79,800	163,000	187,000 r
Consumption, apparent	XX	XX	XX	XX	XX	93,200	8,260	101,000	128,000 r

r Revised. W Withheld to avoid disclosing company proprietary data; included with "Other." XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Under investigation.

[3] Includes batteries, catalysts, ceramics, coinage, other alloys containing nickel, and data indicated by symbol W.

TABLE 5
NICKEL IN CONSUMER STOCKS IN THE UNITED STATES, BY FORM, DECEMBER 31[1]

(Metric tons of contained nickel)

Form	2008 r	2009
Primary:		
Metal	6,850	6,240
Ferronickel	839	733
Oxide and oxide sinter	48	77
Chemicals	1,360	1,350
Other	89	97
Total	9,180	8,500
Secondary, scrap	9,990	9,260
Grand total	19,200	17,800

r Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 6
U.S. EXPORTS OF NICKEL PRODUCTS, BY CLASS[1]

Class	2008 Quantity (metric tons of contained nickel)	2008 Value (thousands)	2009 Quantity (metric tons of contained nickel)	2009 Value (thousands)
Primary:				
Unwrought:				
Cathodes, pellets, briquets, shot	1,380	$32,500	1,100	$16,800
Ferronickel	1	113	32	1,050
Powder and flakes	1,190	55,200	1,110	46,700
Metallurgical-grade oxide[2]	4,140	14,900	627	4,850
Chemicals:[2]				
Catalysts	2,650	205,000	2,870	221,000
Salts[3]	2,260	37,800	1,280	22,500
Total	11,600	345,000	7,020	313,000
Secondary:[2]				
Stainless steel scrap	75,100	1,190,000	84,800	777,000
Waste and scrap	19,500	150,000	5,170	36,200
Total	94,600	1,340,000	90,000	814,000
Grand total	106,000	1,680,000	97,000	1,130,000
Wrought, not alloyed:				
Bars, rods, profiles, wire	360	11,900	233	6,510
Sheets, strip, foil	799	27,300	546	13,100
Tubes and pipes	544	6,320	197	4,630
Total	1,700	45,500	975	24,200
Alloyed, gross weight:				
Unwrought alloyed ingot	7,520	213,000	5,740	128,000
Bars, rods, profiles, wire	20,000	762,000	12,700	414,000
Sheets, strip, foil	7,670	310,000	6,240	197,000
Tubes and pipes	2,770	151,000	1,920	106,000
Other alloyed articles	4,120	295,000	4,110	277,000
Total	42,100	1,730,000	30,700	1,120,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The nickel contents are as follows: metallurgical-grade oxide, 77%; waste and scrap, 50%; and stainless steel scrap, 7.5%. The salts category contains the following: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; and sulfates, 22%. Other salts and various catalysts are assumed to be 22% nickel.

[3] Excludes nickel carbonate.

Source: U.S. Census Bureau.

TABLE 7

U.S. EXPORTS OF NICKEL PRODUCTS, BY COUNTRY[1]

(Metric tons of contained nickel)[2]

	2009									
Country	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferronickel	Metallurgical-grade oxide[3]	Waste and scrap	Stainless steel scrap	Chemicals	Total	Total in 2008	Wrought nickel in 2009[4]
Australia	--	4	--	--	355	14	53	426	475	4
Belgium	34	3	--	6	2	202	184	431	752	7
Brazil	128	34	--	--	--	5	242	409	576	1
Canada	13	105	--	561	2,720	1,470	839	5,700	17,400	229
China	46	95	28	2	48	18,100	351	18,700	7,560	59
Colombia	41	24	--	--	--	2	7	74	60	23
Finland	--	--	--	--	--	2,260	--	2,260	4,210	2
France	(5)	7	--	--	4	53	13	77	250	12
Germany	18	298	(5)	2	233	10	96	657	1,170	49
India	--	12	--	--	92	8,970	386	9,460	6,180	9
Italy	--	3	--	--	--	10	39	52	300	24
Japan	1	79	--	5	617	2,900	80	3,690	13,600	5
Korea, Republic of	17	52	--	--	--	11,400	386	11,800	9,630	139
Mexico	661	33	--	13	343	13	114	1,180	1,280	99
Netherlands	--	(5)	--	--	103	205	85	393	1,820	4
South Africa	--	1	--	--	--	--	11	12	69	2
Spain	--	(5)	--	--	--	741	73	814	996	2
Sweden	--	3	--	--	249	127	1	380	422	1
Taiwan	23	20	--	--	11	29,600	174	29,800	24,300	13
Thailand	--	43	--	2	--	2,160	48	2,260	2,380	4
United Kingdom	1	97	--	--	355	119	136	708	943	40
Other	114	195	4	35	34	6,430	839	7,650	11,900	243
Total	1,100	1,110	32	626	5,170	84,800	4,160	97,000	106,000	971

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The nickel contents are assumed to be as follows: metallurgical-grade oxide, 77%; waste and scrap, 50%; and stainless steel scrap, 7.5%. The chemicals category contains the following: chemical-grade oxide, sesquoxide, and hydroxide, 65%; chlorides, 25%; and sulfate, 22%. Other salts and various catalysts are assumed to be 22% nickel.

[3] Chemical-grade oxide is included in the "Chemicals" category.

[4] Excluded from "2009, total."

[5] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8

U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS, BY CLASS[1]

Class	2008 Quantity (metric tons of contained nickel)	2008 Value (thousands)	2009 Quantity (metric tons of contained nickel)	2009 Value (thousands)
Primary:				
Unwrought:				
Cathodes, pellets, briquets, shot	107,000	$2,550,000	85,500	$1,210,000
Ferronickel	11,000	272,000	6,200	84,900
Powder and flakes	6,040	184,000	4,450	83,700
Metallurgical-grade oxide[2]	1,340	32,000	799	10,800
Chemicals:[2]				
Catalysts	1,800	115,000	1,900	78,200
Salts[3]	1,960	45,100	1,010	17,400
Total	129,000	3,200,000	99,900	1,480,000
Secondary:[2]				
Stainless steel scrap	10,500	217,000	9,310	138,000
Waste and scrap	9,590	210,000	8,430	112,000
Total	20,100	427,000	17,700	249,000
Grand total	149,000	3,630,000	118,000	1,730,000
Wrought, not alloyed:				
Bars, rods, profiles, wire	250	10,500	131	4,260
Sheets, strip, foil	476 [r]	15,900 [r]	195	5,180
Tubes and pipes	221	7,360	83	4,590
Total	947 [r]	33,800 [r]	409	14,000
Alloyed, gross weight:				
Unwrought alloyed ingot	4,440	117,000	4,590	63,600
Bars, rods, profiles, wire	10,600	328,000	6,450	151,000
Sheets, strip, foil	3,380 [r]	126,000 [r]	1,790	41,900
Tubes and pipes	2,460	77,300	1,670	95,500
Other alloyed articles	2,810	99,200	2,820	87,700
Total	23,700 [r]	748,000 [r]	17,300	439,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The nickel contents are as follows: metallurgical-grade oxide from Australia, 90%; elsewhere, 77%. The salts category contains the following: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; sulfates, 22%; and other salts, which are assumed to be 22% nickel. The typical catalyst is assumed to have a nickel content of 22%. Waste and scrap is assumed to be 50% nickel; stainless steel scrap, 7.5% nickel.

[3] Excludes nickel carbonate.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS, BY COUNTRY[1]

(Metric tons of contained nickel)[2]

	2009									
Country	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferronickel	Metallurgical-grade oxide[3]	Waste and scrap	Stainless steel scrap	Chemicals	Total	Total in 2008	Wrought nickel in 2009[4]
Australia	9,450	299	--	787	69	--	1	10,600	16,600	1
Belgium	--	90	--	--	186	--	150	426	427 r	-
Brazil	1,650	--	--	--	73	44	--	1,770	203 r	-
Canada	35,500	2,280	72	--	1,950	6,840	119	46,700	70,200	1
Colombia	--	--	3,750	--	8	42	--	3,800	2,870	-
Dominican Republic	--	--	230	--	--	8	--	238	5,640	-
Finland	5,550	(5)	--	--	7	--	231	5,780	3,280 r	-
France	816	2	--	--	1,150	9	450	2,420	2,080	109
Germany	97	78	--	--	702	27	329	1,230	1,400	180
Indonesia	--	--	149	--	--	--	--	149	50	-
Israel	--	1	--	--	92	1	(5)	94	307	-
Italy	--	--	--	--	21	5	9	35	146	31
Japan	426	50	52	--	273	10	224	1,040	1,370	3
Mexico	--	--	--	--	666	2,030	19	2,710	3,270	(5)
Netherlands[6]	6	10	--	--	72	--	254	342	372	8
New Caledonia	--	--	1,800	--	--	--	--	1,800	2,050	-
Norway	11,200	--	--	--	31	--	--	11,300	10,000	(5)
Russia	19,800	862	--	--	57	--	(5)	20,700	21,200	2
South Africa	83	370	132	--	--	--	--	585	497 r	-
Spain	--	--	--	--	56	7	3	66	104	(5)
Taiwan	--	--	--	--	48	98	--	146	71	-
United Kingdom	342	393	13	12	1,660	48	107	2,580	3,570	17
Zimbabwe	514	--	--	--	--	--	--	514	667	-
Other	20	17	--	1	1,310	147	1,020	2,510	2,460 r	57
Total	85,500	4,450	6,200	799	8,430	9,310	2,910	118,000	149,000	409

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The nickel contents are assumed to be as follows: metallurgical-grade oxide from Australia, 90%; elsewhere, 77%. The chemicals category contains the following: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; sulfates, 22%. Other salts and various catalysts are assumed to be 22% nickel. Waste and scrap is assumed to be 50% nickel; stainless steel scrap, 7.5% nickel.

[3] Primarily oxide, rondelles, and sinter.

[4] Excluded from "2009, total."

[5] Less than ½ unit.

[6] The different nickel products (cathode, powder, etc.) are apparently materials that have transited through bonded warehouses in the Netherlands, including warehouses overseen by the London Metal Exchange.

Source: U.S. Census Bureau.

TABLE 10
NICKEL: WORLD MINE PRODUCTION, BY COUNTRY[1]

(Metric tons of contained nickel)

Country and products[2]	2005	2006	2007	2008	2009
Albania, laterite ore[e]	10 [r]	790 [r]	3,700 [r]	3,500 [r]	3,500
Australia, ores and concentrate[3]	188,900	185,000	184,900	199,200	165,000
Botswana, ore milled	39,305	38,000 [e]	27,600 [r, e]	28,940 [r]	28,595
Brazil, ore	74,198	82,492	58,317	67,116 [r]	67,000 [p]
Burma, ore[e]	10	10	10	10	10
Canada, concentrate	199,932	232,948	254,915	259,651 [r]	136,594
China[e]	72,700	82,100	67,000	72,000	79,355 [4]
Colombia, laterite ore	89,031	94,105	100,539 [r]	77,000 [r]	72,000
Cuba, oxide, oxide sinter, oxide powder, sulfide, ammoniacal liquor[5]	73,753	73,371	73,934	67,265	65,000 [e]
Dominican Republic, laterite ore	53,124	47,516	47,125	31,300	--
Finland, concentrate[6]	3,386	2,985	3,635	4,303 [r]	4,400 [e]
Greece, laterite ore	23,210	21,670	21,190	18,646 [r]	10,203
Indonesia, laterite ore	135,000	157,000	229,000	192,600	202,800
Kazakhstan, laterite ore[e]	193 [4]	200	200	500	500
Kosovo, laterite ore[7, 8]	--	--	1,820 [r]	3,660 [r]	3,960
Macedonia, ferronickel produced[8]	8,141	10,942	15,321	15,026	11,990 [p]
Morocco, nickel sulfate	199 [e]	80	100	100 [e]	100 [e]
New Caledonia, ore	111,939	102,986	125,364	102,583 [r]	92,846
Norway, concentrate	342	320	240	377 [r]	369
Philippines:					
Ore	22,555 [r]	56,463 [r]	81,288	70,082 [r]	120,316
Concentrate[9]	4,081	8,242	10,079	10,562	17,035
Total	26,636 [r]	64,705 [r]	91,367	80,644 [r]	137,351
Russia, marketable mine production:					
Laterite ore[10]	34,419	37,754	45,690	36,807	32,359
Sulfide concentrate[11]	242,758	239,231	234,083	230,000	229,493
Total	277,177	276,985	279,773	266,807	261,852
South Africa, concentrate	42,392	41,599	37,917	31,675	34,606
Spain, concentrate	5,386 [r]	6,398 [r]	6,772 [r]	8,136 [r]	8,029
Turkey, laterite ore[e]	1,000	1,500	--	--	--
Ukraine, laterite ore[e]	6,000	12,000	12,000	8,000	--
Venezuela, laterite ore	21,100 [r]	21,200 [r]	18,900 [r]	13,000 [r]	13,200
Zambia, concentrate[12]	--	--	--	751	300
Zimbabwe, concentrate	9,220 [r]	8,825	8,582 [r]	6,354	5,000 [e]
Grand total	1,460,000 [r]	1,570,000	1,670,000 [r]	1,560,000 [r]	1,400,000
Of which:					
Concentrate[13]	507,000	541,000 [r]	556,000 [r]	552,000 [r]	436,000
Ore and ore milled	248,000 [r]	280,000 [r]	293,000 [r]	269,000 [r]	309,000
Laterite ore	363,000	394,000 [r]	480,000 [r]	385,000 [r]	339,000
Ferronickel produced	8,140	10,900	15,300	15,000	12,000 [p]
Nickel sulfate	199 [e]	80	100	100 [e]	100 [e]
Unspecified and (or) undifferentiated	335,000	340,000	326,000	338,000	309,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Insofar as possible, this table represents recoverable mine production of nickel. Where actual mine output is not available, data related to a more highly processed form have been used to provide an indication of the magnitude of mine output and this is noted. North Korea may have an active nickel mine, but information is inadequate to make reliable estimates of output. Table includes data available through August 13, 2010.

[3] Australian Bureau of Agricultural and Resource Economics (ABARE) data for mines in Western Australia and Tasmania.

[4] Reported figure.

[5] The Government of Cuba reports plant production on a contained nickel plus cobalt basis. The tonnages shown in this table for Cuba have been adjusted downward to correct for the cobalt. The cobalt content was determined to be 1.16% for granular and powdered oxide, 1.21% for oxide sinter, 7.56% for sulfide precipitate, and 33% for leach ammoniacal precipitate.

[6] The gross weight of concentrates processed in Finland from domestic ores was, in metric tons, as follows: 2005—39,854; 2006—40,474 (revised); 2007—44,824 (revised); 2008—43,038 (revised); and 2009—43,000 (estimated).

TABLE 10—Continued
NICKEL: WORLD MINE PRODUCTION, BY COUNTRY[1]

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[7] On February 17, 2008, the Kosovo Assembly declared independence from Serbia.

[8] Cunico Resources N.V. (Amsterdam, Netherlands) shipped lateritic ore from Albania to the company's smelter at Kavadarci in Macedonia. The ore came from the Bitinçka and Treni Mines in the Devolli region close to the Greek border. The Kavadarci smelter and Cunico's sister smelter at Gllogovac, Kosovo, also received Albanian ore from a third party.

[9] Nickel content of concentrate produced at Rio Tuba by Coral Bay Nickel Corp.

[10] Nickel content of ore mined in the Ural Mountains region.

[11] Nickel content of concentrate produced on the Kola and Taimyr Peninsulas.

[12] Albidon Limited concentrates were shipped to Jinchuan Ltd. in China. First production was in June 2008. Anticipated specifications for concentrates are 13% nickel and 0.7% cobalt. Concentrate production comes from company quarterly reports.

[13] Includes "Russia, sulfide concentrate."

TABLE 11
NICKEL: WORLD PRODUCTION OF INTERMEDIATE PRODUCTS FOR EXPORT, BY COUNTRY[1, 2]

(Metric tons of contained nickel)

Country	2005	2006	2007	2008	2009
Matte:					
Australia[3]	44,536	39,561	41,612	31,085	35,441
Botswana	28,212	26,762	22,844	28,940 ^{r}	29,616
Brazil[4]	6,005	5,416	3,401	3,153 ^{r}	3,200 ^{p}
Canada[5]	59,722	56,628	73,922	76,908 ^{r}	68,972 ^{p}
China[6]	26	758	1,980	3,240	--
Indonesia[7]	77,471	72,782	77,928	73,356 ^{r}	68,300 ^{p}
New Caledonia	12,838	13,655	14,842 ^{r}	13,564 ^{r}	13,902
Russia[8]	700	1,300	670 ^{e}	600 ^{e}	240 ^{e}
Zimbabwe[e, 9]	1,400	1,600	1,400	2,000	2,500
Total	231,000	218,000	239,000 ^{r}	233,000 ^{r}	222,000
Other, Cuba:[10]					
Sulfide precipitate	32,354	30,967	31,116	32,465	32,500 ^{e}
Ammoniacal liquor precipitate	2,278	3,283	2,907	322	300 ^{e}
Total	34,632	34,250	34,023	32,787	32,800 ^{e}

^{e}Estimated. ^{p}Preliminary. ^{r}Revised. -- Zero.

[1] Table includes data available through August 13, 2010. Data represent nickel content of matte and other intermediate materials produced.

[2] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[3] Figures exclude toll-refined material.

[4] Represents the output of the Fortaleza smelter. All of the Fortaleza matte is shipped to Finland for further processing.

[5] Nickel content of reported exports. Matte from the smelter at Falconbridge typically assays 55% nickel.

[6] Chinese exports were estimated to have a nickel content of 63%. Total matte production on a contained nickel basis, in metric tons, was estimated as follows: 2005—83,500; 2006—99,800; 2007—105,000; 2008—110,000; and 2009—120,000.

[7] Represents the nickel output of the Soroako smelter. The Soroako matte is shipped to Japan for further processing and contains on average 78% nickel.

[8] Primarily exports to China. Sources: International Nickel Study Group; United Nations Statistics Division.

[9] Zimbabwe Platinum Mines Limited (Zimplats) of Delta Gold Limited (Delta) material shipped to the Impala Refining Services PGM Refinery of Impala Platinum Holdings Limited (Implats) at Springs, South Africa.

[10] Corrected to remove coproduct cobalt.

TABLE 12
NICKEL: WORLD PLANT PRODUCTION, BY COUNTRY AND PRODUCT[1, 2]

(Metric tons of contained nickel)

Country and product[3]	2005	2006	2007	2008	2009
Australia:					
Metal	112,600	105,100	100,300	89,500	123,200
Unspecified[4]	9,700	11,400	14,200 [r]	19,400 [r]	8,000
Total	122,300	116,500	114,500 [r]	108,900 [r]	131,200
Austria, ferronickel and ferronickel molybdenum[e]	1,000	900	900	500 [r]	700
Brazil:[5]					
Ferronickel	9,596	9,814	9,918	10,244 [r]	9,453 [p]
Metal	20,714	21,339	21,635	18,530 [r]	20,056 [p]
Total	30,310	31,153	31,553	28,774 [r]	29,509 [p]
Canada, unspecified[6]	139,683	146,899	153,647	167,732	116,909
China:[7]					
Ferronickel and high nickel pig iron	2,900	31,000	84,500	70,900	100,000
Metal	95,100	102,000	116,000	129,000	165,000
Chemicals and unspecified[e]	5,000	5,000	6,000 [8]	8,000 [8]	8,000
Total	103,000	138,000	206,500	207,900	273,000
Colombia, ferronickel	52,749	51,137	49,314 [r]	41,636	51,802
Cuba, oxide sinter and oxides[9]	39,121	39,121	39,911	34,478	34,500 [e]
Dominican Republic, ferronickel	28,668	29,675 [r]	29,128 [r]	18,742 [r]	--
Finland:[10]					
Metal	34,709	42,299	49,700	42,971 [r]	41,848
Chemicals and unspecified	4,450	5,170	5,200	8,142 [r]	5,000 [e]
Total	39,159	47,469	54,900	51,113 [r]	46,848
France:					
Metal	10,500	11,400	11,200	11,500	11,900
Chemicals[e]	2,000	2,000	2,000	2,000	2,000
Total[11]	12,500	13,400	13,200	13,500	13,900
Greece, ferronickel	19,235	17,740	18,670	16,640 [r]	8,269
India:[12]					
Ferronickel	--	(13)	(13)	(13)	(13)
Ferronickel magnesium	--	41	52	93	88
Nickel sulfate	--	(14)	(14)	(14)	(14)
Total	--	41	52	93	88
Indonesia, ferronickel	7,338	14,474	18,532 [r]	17,566 [r]	12,550
Japan:					
Ferronickel	76,390	66,668	68,346	59,259 [r]	58,936
Metal	29,399	29,254	30,402	34,861 [r]	30,200
Oxide sinter	56,700	53,877	60,151	54,900 [r, e]	57,190
Chemicals	2,208	2,531	2,270	2,333 [r]	1,671
Total	164,697	152,330	161,169	151,353 [r]	147,997
Korea, Republic of:					
Ferronickel	--	--	--	2,506	21,609 [p]
Metal	(15)	(15)	(15)	(15)	(15)
Total	(15)	(15)	(15)	2,506	21,609 [p]
Kosovo, ferronickel[e, 16]	--	--	800	7,100	4,700
Macedonia, ferronickel	8,141	10,942	15,321	15,026	11,990 [p]
Morocco, chemicals[e]	130	125	125	125	125
New Caledonia, ferronickel	46,738	48,723	44,954	37,467	38,230
Norway, metal	84,886	81,974	87,590	88,741	88,577
Poland, chemicals[17]	453	465	475 [e]	475 [e]	475 [e]
Russia:					
Ferronickel:					
High-nickel	12,600	14,436	17,111	16,158	15,565
Other[e, 18]	4,290 [r]	4,490 [r]	4,690 [r]	4,905 [r]	5,125
Metal	249,479	255,045	248,363	242,409	237,270

See footnotes at end of table.

TABLE 12—Continued
NICKEL: WORLD PLANT PRODUCTION, BY COUNTRY AND PRODUCT[1, 2]

(Metric tons of contained nickel)

Country and product[3]	2005	2006	2007	2008	2009
Russia—Continued:					
Oxide sinter	4,075	2,713	235	--	--
Chemicals[e]	3,200	3,500	3,100	2,900	2,700
Total	273,644 [r]	280,184 [r]	273,499 [r]	266,372 [r]	260,660
South Africa:					
Ferronickel, high-nickel	90	100	5,000	4,300	800
Metal	42,400	41,800	34,400	30,200 [r]	34,000 [e]
Chemicals[e, 19]	7,400	7,600	6,800	6,800	6,800
Total	49,890 [r]	49,500 [r]	46,200 [r]	41,300 [r]	41,600 [e]
Taiwan, metal	(15)	(15)	(15)	(15)	(15)
Ukraine, ferronickel[20]	14,211 [r]	15,223 [r]	12,074 [r]	16,224 [r]	12,392
United Kingdom, metal[21]	37,127	36,770	34,064	41,000 [r]	17,800 [p]
Venezuela, ferronickel	16,900	16,600	15,700 [r]	10,900 [r]	10,400
Zimbabwe, metal:[e]					
Refined from domestic nickel ore	7,500	5,510 [8]	4,500	3,400	--
Toll refined from imported nickel feed[22]	5,700	9,000	9,500	10,300	5,000
Total	13,200	14,510 [8]	14,000	13,700	5,000
Grand total	1,310,000 [r]	1,350,000	1,440,000 [r]	1,400,000 [r]	1,380,000
Of which:					
Ferronickel, including ferronickel magnesium	301,000 [r]	332,000 [r]	395,000 [r]	350,000 [r]	363,000
Metal	730,000	741,000	748,000	742,000 [r]	775,000
Oxide sinter	99,900	95,700	100,000	89,400 [r]	91,700
Chemicals, including nickel sulfate	15,400	16,200	14,800	14,600	13,800
Unspecified	159,000 [r]	168,000 [r]	179,000 [r]	203,000 [r]	138,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 13, 2010.

[3] In addition to the countries listed, North Korea is thought to have produced metallic nickel and (or) ferronickel, but information is inadequate to make reliable estimates of output levels. Several countries produce nickel-containing matte, but output of nickel in such materials has been excluded from this table to avoid double counting. Countries producing matte for export are listed in table 11.

[4] Class II products with a nickel content of less than 99%. Includes oxides and oxide sinter. Excludes intermediate nickel-cobalt sulfide matte, regulus, and speiss for further refining.

[5] Brazil produced nickel carbonate (an intermediate product for metal production), in metric tons: 2005—21,116; 2006—21,630; 2007—20,796; and 2008–09—20,800 (estimated).

[6] Nickel contained in products of smelters and refineries in forms that are ready for use by consumers. Figures include the nickel content of nickel oxide sinter exported to the Republic of Korea and Taiwan. More information can be found in footnote 15.

[7] Figures for ferronickel and chemicals were derived from data published by Beijing Antaike Information Development Co. Ltd. Figures for electrolytic and other class I nickel are based on data provided by the China Nonferrous Metals Industry Association and the International Nickel Study Group. In 2006–09, China also produced nickeliferous pig iron from lateritic ores imported from Indonesia, New Caledonia, and the Philippines.

[8] Reported figure.

[9] Cuba also produces nickel sulfide and ammoniacal liquor precipitate, but because they are used as feed material elsewhere, they are not included to avoid double counting. More information can be found in table 11.

[10] Most of the production is extracted from imported raw materials.

[11] Reported by Eramet Group for Sandouville. Excludes secondary production from spent rechargeable batteries.

[12] Fiscal year ending March 31 of that stated.

[13] Vidarbha Nickel Pvt. Ltd. of Nagpur, Maharashtra State, has produced ferronickel from spent nickel catalysts, but no production data were available.

[14] Nickel sulfate was produced in the past as a byproduct at the Ghatsila copper smelter in Jharkhand State. The facility is capable of producing 390 tons (gross weight) per year of nickel sulfate, but no production data were available.

[15] Nickel metal production for the Republic of Korea and Taiwan are not included because the production is derived wholly from imported metallurgical-grade oxides and to include them would result in double counting. Metal production figures are as follows, in metric tons: Republic of Korea: 2005—26,300 (estimated); 2006—28,085; 2007—28,675; 2008—28,653; and 2009—28,000 (estimated). Taiwan: 2005–09—11,000 (estimated).

[16] On February 17, 2008, the Kosovo Assembly declared independence from Serbia.

TABLE 12—Continued

NICKEL: WORLD PLANT PRODUCTION, BY COUNTRY AND PRODUCT[1, 2]

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[17] Nickel content of nickel sulfate. Most of the nickel sulfate was a byproduct of the concentrating, smelting, and refining of domestically mined copper ores. Some production, however, may have been derived from imported nickeliferous raw materials that were blended with the domestic copper concentrates.

[18] Includes ferronickel chromium and Ni-resist cast iron.

[19] Includes nickel sulfate plus exported metal in concentrate.

[20] May include nickel in remelt alloys derived from scrap.

[21] Includes nickel contents of chemicals.

[22] Data represent production from matte imported from Botswana and nickel sulfate imported from South Africa.

TABLE 13
NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2015

Projected year of first production	Country (state/province)	Project and company[1]	Resource grade (% nickel)	Estimated resources (thousand metric tons)[2]	Annual production capacity (metric tons of contained nickel)	Nickel product
2010	Brazil (Para)	Onca-Puma Mineração Onça Puma Vale Inco Ltd.	1.72 0.75	110,000 314,000	58,000	Ferronickel.
2010	New Caledonia (Southern)	Vale Nouvelle-Calédonie[3] Vale Inco Nouvelle-Calédonie S.A.S.[4] Vale Inco Ltd., Société de Participation Minière du Sud Calédonien S.A.S., and Sumitomo consortium	1.34 2.01 1.70	96,000 24,000 83,000	60,000	Nickel oxide.
2011	Australia (Queensland)	Lucky Break (Circular Laterite and Dingo Dam) Metallica Minerals Ltd. and Metals Finance Corp.	0.82 0.82 0.75	590,000 48,000 490,000	730	Nickel carbonate.
2011	Brazil (Goias)	Barro Alto Anglo American plc	1.30 1.27 1.45	3,500 16,600 61,000	36,000	Ferronickel.
2011	Madagascar	Ambatovy (Ambatovy and Analamay deposits) Sherritt International Corp., Sumitomo Corp., South Korean consortium, and SNC-Lavalin Group Inc.	1.12 0.99	44,000 81,000	60,000	Nickel metal powder and briquettes.
2011	Papua New Guinea (Madang)	Ramu China Metallurgical Group Corp. consortium, Highlands Pacific Ltd., and Mineral Resources Development Co.	0.91 1.01	76,000 67,000	33,000	Nickel-cobalt hydroxide.
2012	Burma (Thabeikkyin, Mandalay)	Tagaung Taung China Nonferrous Metals Mining Group Co., Ltd. and Government of Burma	2.02	40,000	22,000	Ferronickel.
2012	Indonesia (Sulawesi)	Morowali PT Sinosteel Indonesia Mining	1.50	500,000	7,500	Direct shipping ore.
2012	Philippines (Surigao del Norte and Surigao del Sur)	Adlay-Cagdianao-Tandawa CTP Construction and Mining Corp.	1.61 1.58	5,800 13,000	5,000	Do.
2013	Australia (Western Australia)	Yerilla (Aubils, Boyce Creek, and Jump-up Dam) Heron Resources Ltd. and Ningbo Shanshan Co. Ltd.	1.01 0.77	22,000 110,000	5,000	Iron-nickel-cobalt alloy.
2013	New Caledonia (Northern)	Koniambo (saprolite ores) Xstrata Nickel and Soc. Miniere du Sud Pacifique S.A.	2.54 2.45 2.50	21,000 54,000 83,000	60,000	Ferronickel.
2013	Philippines (Surigao del Norte)	Agata Mindoro Resources Ltd.	1.00 1.16 [5] 0.98 1.18 [5] 1.06	1,400 640 8,400 17,000 3,800	7,500	Ore initially.
2014	Australia (Queensland)	Marlborough (Coorumburra, Slopeaway, and Whereat)[6] Gladstone Pacific Nickel Ltd.	0.99 0.91 0.88	12,000 43,000 16,000	63,000	Metal.
2014	Do.	Nornico-Greenvale (Bell Creek, Greenvale, Kokomo, and Minnamoolka deposits) Metallica Minerals Ltd.	0.81	46,000	10,000	Do.
2014	Australia (Western Australia)	NiWest (Eucalyptus, Hepi, and Mt. Kilkenny) GME Resources Ltd.	1.18 1.14 1.13	19,000 8,500 3,700	30,000	Nickel-cobalt sulfide.
2014	Do.	Kalgoorlie (Goongarrie and Siberia) Heron Resources Ltd.[7]	0.74 0.69	320,000 270,000	36,000	Nickel-cobalt hydroxide.

See footnotes at end of table.

TABLE 13—Continued
NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2015

Projected year of first production	Country (state/province)	Project and company[1]	Resource grade (% nickel)	Estimated resources (thousand metric tons)[2]	Annual production capacity (metric tons of contained nickel)	Nickel product
2014	Cameroon (East Province)	Nkamouna and Mada Geovic Cameroon PLC.	0.68 0.62 0.58	60,000 61,000 183,000	3,200	Cobalt-nickel sulfide.
2014	Kazakhstan (Kostanai Oblast)	Shevchenko OAO Mechel	0.85 0.77 0.84	21,000 83,000 32,000	15,700	Ferronickel or nickel-cobalt hydroxide.
2014	Philippines (Mindoro Oriental)	Mindoro/Sablayan (Buraboy, and Kisluyan, Shabo areas) Aglubang Mining Corp., local partner of and Intex Resources ASA	0.83 0.77	220,000 88,000	60,000	Nickel-cobalt sulfide intermediate, initially.
2014	Philippines (Surigao del Norte and Surigao del Sur)	Taganito Sumitomo Metal Mining Co. Ltd. and Nickel Asia Corp.	(8)	(8)	30,000	Nickel-cobalt sulfide intermediate.
2014	Philippines (Zambales)	Acoje and Zambales DMCI Holdings, Inc., Rusina Mining NL, and European Nickel PLC	1.09 1.01 1.18	34,000 16,000 24,000	24,500	Nickel-cobalt hydroxide.
2014	Turkey (Manisa)	Caldag European Nickel PLC and Jiangxi Rare Earth and Rare Metals Tungsten Group Co., Ltd.	1.13	33,000	21,000	Do.
2015	Albania	Devolli and Kokogllave Balkan Resources Inc. and European Nickel PLC	1.19 1.21 1.20	22,000 14,000 30,000	15,000	Do.
2015	Brazil (Para)	Araguaia (Pau Preto, Serra do Tapa, and Vale dos Sonhos) Xstrata Nickel	1.44 1.31 1.30	16,000 89,000 18,000	36,000	Ferronickel.
2015	Do.	Jacaré Anglo American plc	1.19 1.16 1.54 [5] 1.36 [5]	99,000 81,000 25,000 85,000	34,000	Do.
2015	Do.	Vermelho Vale Inco Ltd.	1.25 0.80	124,000 148,000	46,000	Metal or oxide.
2015	China (Yunnan)	Yuanjiang Yuanjiang Nickel Co., Ltd., subsidiary of Sino-Platinum Metals Corp., Ltd.	0.91	430,000	5,000	Nickel-cobalt intermediate.
2015	Cuba (Holguin)	Las Camariocas Government of Cuba, Ferroniquel S.A., and others	1.32	110,000	22,500	Ferronickel.
2015	Guatemala (Izabal)	Fenix saprolite (pyrometallurgical process) Cia. Guatemalteca de Niquel S.A., subsidiary of Hudbay Minerals Inc.[9]	2.09 [5] 1.87 [5] 1.80 [5]	7,700 28,000 9,700	22,700	Do.
2015	Indonesia (Halmahera Island)	Weda Bay (Boki, Mokot, Pintu, and Santa Monica deposits) PT Weda Bay Nickel (Eramet Group and Mitsubishi Corp.) and PT Aneka Tambang	1.45 1.53	154,000 123,000	60,000	NA.[10]
2015	Indonesia (Sulawesi)	Sorowako and Bahodopi mines PT International Nickel Indonesia TBK	1.87 [5]	48,000	22,000	Ore for blending and subsequent conversion to matte.
2015	Philippines (Davao Oriental)	Pujada—Mati Hallmark Mining Corp. and Austral-Asia Link Mining Corp.[11]	1.30	200,000	50,000	Nickel-cobalt intermediate.

Do. Ditto. NA Not available.

[1] Company names reflect organizational structure as of December 31, 2009. BHP Billiton Group is a dual listed company comprising BHP Billiton Ltd. and BHP Billiton Plc. Vale Inco Ltd. is a wholly owned subsidiary of Companhia Vale do Rio Doce.

NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2015

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[2] Gross weight, dry. "Estimated resources" are rounded to no more than two significant digits. When two or more data sets are listed, the first resource data represent measured resources; the second, indicated resources; and the third, inferred resources.

[3] On December 19, 2008, the name of the project—Goro—was changed to Vale Inco Nouvelle-Calédonie.

[4] Vale Inco Nouvelle-Calédonie was renamed Vale Nouvelle-Calédonie in May 2010.

[5] Saprolite.

[6] The Marlborough ores would be supplemented with ores from the mines of Societe des Mines de la Tontouta and Societe Miniere Georges Montagnat in New Caledonia.

[7] Vale Inco Ltd. withdrew from the Kalgoorlie Nickel Project in July 2009 after spending $34 million on feasibility studies.

[8] Nickel Asia Corp. could provide ore from several mine sites on Mindanao Island.

[9] HudBay Minerals Inc. acquired Skye Resources Inc. in August 2008.

[10] Proprietary process currently under development by Centre de Recherche de Trappes (France).

[11] In December 2009, BHP Billiton Group withdrew from the Pujada project and sold its 40% interest to its local partner, Asiaticus Management Corp. (AMCOR).

Sources: Company annual reports, presentations, and press releases; CRU International, Ltd.

TABLE 14
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2015

Projected year of first production[1]	Country (state/province)	Project and company[2]	Resource grade (% nickel)	Estimated resources (thousand metric tons)[3]	Annual production capacity (metric tons of contained nickel)	Nickel product
2009/2011	Canada	Nickel Rim South	1.65	2,800	18,000	Ore.
	(Ontario)	Xstrata Nickel	1.48	2,500		
			1.40	13,000		
2010	Australia	Lounge Lizard[4]	4.83	630	2,300	Do.
	(Western Australia)	Kagara Ltd. and Western Areas NL	4.37	520		
2010	Do.	Spotted Quoll	5.90 [5]	1,700	10,000	Concentrate.
		Western Areas NL	6.40 [5]	230		
			4.10 [6]	1,700		
2010/2012	Canada	Fraser Morgan	1.94	4,400	6,000	Ore.
	(Ontario)	Xstrata Nickel	1.81	2,400		
			1.70	1,800		
2010	Do.	McWatters	0.70	870	2,600	Do.
		Liberty Mines Inc.[7]				
2010[8]	Do.	Shakespeare	0.33 [5]	12,000	4,100	Ore initially.
		Ursa Major Minerals Inc.	0.37	1,800		Concentrate.
			0.37	700		
2011	Australia	Sinclair (underground)	(9)	(9)	5,500	Concentrate.
	(Western Australia)	Xstrata Nickel Australasia[10]				
2011	Canada	Totten (plus new Clarabelle mill addition)	0.74	6,000	8,200	Do.
	(Ontario)	Vale Inco Ltd.	0.75	550		
2012	Australia	Cosmic Boy and Diggers[11]	1.46 [12]	2,100	7,000	Do.
	(Western Australia)	Western Areas NL	2.40 [13]	380		
			1.00 [14]	10,000		
2012	Finland	Kevitsa	0.31	110,000	10,000	Do.
	(Lappi)	First Quantum Minerals Ltd.	0.30	55,000		
			0.29	290,000		
2012	Finland	Outokumpu Copper (formerly Kylylahti copper-	0.17	620	1,400	Zinc-cobalt-copper-
	(Pohiois)	cobalt)	0.20	7,500		nickel concentrate.
		Altona Mining Ltd.[15]	0.18	310		
2012	Vietnam	Ban Phuc	2.68 [16]	1,700	6,400	Concentrate.
	(Son La)	Asian Mineral Resources Ltd. and Son La	1.94 [16]	170		
		Mechanical Engineering JSC	0.59 [17]	13,000		
			0.56 [17]	7,400		
2013	United States	Eagle	3.47	3,600	17,300	Do.
	(Michigan)	Kennecott Minerals Co.	3.16	500		
2013	United States	NorthMet	0.08	580,000	7,100	Concentrate initially.
	(Minnesota)	PolyMet Mining Corp.	0.08	230,000		Byproduct nickel-
						cobalt hydroxide.
2014	Australia	Prospero	6.39	420	10,000	Concentrate.
	(Western Australia)	Xstrata Nickel Australasia[10]	6.42	470		
			5.03	450		
2014	Canada	Makwa (formerly Maskwa)	0.55	10,000 [18]	4,200	Do.
	(Manitoba)	Mustang Minerals Corp.	0.25	1,700		
2014	Do.	Minago	0.59	10,000	11,000	Do.
		Victory Nickel Inc.	0.50	39,000		
			0.53	13,000		
2014	Canada	Nunavik/South Raglan (Allammaq, Mesamax,	0.93	560	6,800	Do.
	(Quebec)	Mequillon, Expo, Ivakkak, and TK deposits)	0.93	21,000		
		Jilin Jien Nickel Industry Co., Ltd. and	0.73	5,200		
		Goldbrook Ventures Inc.[19]				
2014	China	Heishan	0.50	30,000	5,000	Do.
	(Gansu)	Jinchuan Group Ltd.				

See footnotes at end of table.

TABLE 14—Continued
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2015

Projected year of first production[1]	Country (state/province)	Project and company[2]	Resource grade (% nickel)	Estimated resources (thousand metric tons)[3]	Annual production capacity (metric tons of contained nickel)	Nickel product
2014	Tanzania (Kagera region)	Kabanga Barrick Gold Corp. and Xstrata Nickel	2.48 2.65 2.90	14,000 24,000 16,000	10,000	Concentrate.
2014	United States (Minnesota)	Birch Lake, Maturi, Spruce Road Franconia Minerals Corp.	0.18 [20] 0.17 [21] 0.25 [22] 0.14 [23]	130,000 40,000 120,000 380,000	8,600	Byproduct nickel-cobalt hydroxide.
2015	Australia (Western Australia)	New Morning/Daybreak Western Areas NL	3.70 [16] 3.50 [16] 0.90 [17] 0.90 [17]	320 93 1,100 660	3,000	Ore.
2015	Do.	Sherlock Bay Australasian Resources Ltd.	0.40	25,000	8,500	Bioleachate precipitate.
2015	Canada (Ontario)	Onaping Depth Xstrata Nickel	2.67 3.60	15,000 1,200	10,000	Ore.
2015	Finland (Oulu)	Kuhmo (Arola, Peura-aho, Hietaharju, Sika-aho, and Vaara) Altona Mining Ltd.[15] and Polar Mining Oy	0.55	6,000	3,000	Concentrate.
2015	Russia (Amur)	Kun-Manie (Vodorazdelny, Ikensoe, Maly Krumkon, and Falcon) Amur Minerals Corp.	0.61 0.48 0.54	3,700 48,000 17,000	16,000	Do.
2015	South Africa (Mpumalanga)	Sheba's Ridge Anglo Platinum Ltd., Aquarius Platinum Ltd., and Industrial Development Corp. of South Africa[24]	0.18 0.18 0.17	409,000 313,000 53,000	24,000	Matte.
2015	United States (Minnesota)	Nokomis/Maturi Extension Twin Metals Minnesota LLC (Duluth Metals Ltd. and Antofagasta PLC)	0.20 0.21	550,000 270,000	10,800	Byproduct nickel-cobalt sulfide or hydroxide.
2015	Zimbabwe	Hunters Road Bindura Nickel Corp.	0.54	45,000	2,000	Concentrate.

Do. Ditto.

[1] Two years are shown for selected newly commisioned projects where the company is ramping up production.

[2] Company names reflect organizational structure as of December 31, 2009. BHP Billiton Group is a dual listed company comprising BHP Billiton Limited and BHP Billiton Plc. Vale Inco Ltd. is a wholly owned subsidiary of Companhia Vale do Rio Doce.

[3] Gross weight, dry. "Estimated resources" are rounded to no more than two significant digits. When two or more data sets are listed, the first resource data represent measured resources; the second, indicated resources; and the third, inferred resources, unless otherwise specified.

[4] The Lounge Lizard deposit was to be developed as part of Western Areas NL's Flying Fox underground operation.

[5] Open pit.

[6] Underground.

[7] Jilin Jien Nickel Industry Co., Ltd. (China) acquired 51% of Liberty Mines in April 2009.

[8] Test shipments of ore were made in 2008.

[9] The Sinclair deposit remains open at depth.

[10] The Sinclair mining complex was acquired by Xstrata Nickel from Jubilee Mines NL in February 2008. Work was suspended temporarily in April 2009 in response to weak nickel prices.

[11] Includes Diggers Rocks, Diggers South, Purple Haze, and Seagull resources.

[12] Diggers areas, probable ore reserves.

[13] Cosmic Boy area indicated resources.

[14] Diggers areas indicated resources.

[15] Altona Mining Ltd. was created when Universal Resources Ltd. merged with Vulcan Resources Ltd. in February 2010.

[16] Massive sulfides.

[17] Disseminated sulfides.

[18] Mustang Minerals Corp. was also evaluating the potential of resources at the nearby Mayville property.

[19] Jilin Jien Nickel Industry Co., Ltd. and Goldbrook Ventures Inc. completed their acquisition of Canadian Royalties Inc. on January 12, 2010.

[20] Birch Lake deposit indicated resource.

TABLE 14—Continued
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2015

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[21] Birch Lake deposit inferred resource.

[22] Maturi deposit resource.

[23] Spruce Road open pit resource.

[24] Aquarius Platinum Ltd. acquired Ridge Mining plc in July 2009 and took over management of Sheba's Ridge in August.

Sources: Canadian Minerals Yearbook 2008, 2009; company annual reports, presentations, and press releases; and CRU International, Ltd.

NIOBIUM (COLUMBIUM) AND TANTALUM

By John F. Papp

Domestic survey data and tables were prepared by Robin C. Kaiser, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2009, U.S. niobium apparent consumption (measured in contained niobium) was 4,210 metric tons (t), 50% less than that of 2008; U.S. tantalum apparent consumption (measured in contained tantalum) was 473 t, 25% less than that of 2008. No domestic mine production of niobium or tantalum ore was reported. The leading use of niobium was as an alloying element in high-strength low-alloy steel. The leading use of tantalum was in electronic capacitors.

Legislation and Government Programs

The Defense National Stockpile Center (DNSC) planned to dispose of niobium and tantalum materials under its fiscal year 2009 Annual Materials Plan (AMP) and announced the fiscal 2010 plan. The DNSC sold no niobium or tantalum materials in calendar year 2009. The DNSC's fiscal year 2010 AMP set maximum disposal goals for niobium and tantalum materials (niobium materials measured in contained niobium, and tantalum materials measured in contained tantalum) as follows: columbium metal, 4,536 kilograms (kg), and tantalum carbide, 1,814 kg (Defense National Stockpile Center, 2009, p. 1). The DNSC suspended the sale of niobium and tantalum materials while it performed a congressionally directed review of the stockpile configuration (Defense National Stockpile Center, 2008, p. 1–2).

Production

The major marketable niobium materials are ferroniobium, nickel-niobium, and niobium metal, ore, and oxide. The major marketable tantalum materials are tantalum metal, ore, and powder. In 2009, neither niobium nor tantalum domestic mine production was reported. The Kougarok prospect, on the Seward Peninsula in Alaska, hosts significant tantalum resources in a lithium-fluorine granite (Hudson, 1998, p. 151–153; Navigator Exploration Corp., 2003, p. 2).

Consumption

Domestic data for niobium and tantalum materials were developed by the U.S. Geological Survey (USGS) by means of the "Columbium (Niobium) and Tantalum," "Consolidated Consumers," and "Specialty Ferroalloys" surveys. For niobium and tantalum materials, there was one respondent to the "Columbium (Niobium) and Tantalum" canvass, about 70 respondents to "Consolidated Consumers" canvass, and one respondent to the "Specialty Ferroalloys" canvass.

In the United States, niobium was consumed by the metallurgical industry; tantalum, by the electronics industry. Niobium masteralloys—ferroniobium and niobium-nickel alloy—were consumed to produce steel and superalloys. About 75% of world niobium consumption was for the production of microalloyed steel (Companhia Brasileira de Metalurgia e Mineração, undated c). Tantalum was consumed to produce capacitors and superalloys. More than 70% of tantalum is consumed by the electronics industry, and most of that goes into making capacitors (Serjak and others, 2002).

Prices

Niobium and tantalum materials are not openly traded. Purchase contracts are confidential between buyer and seller; however, trade journals report composite prices of tantalite based on interviews with buyers and sellers, and traders declare the value of niobium and tantalum materials that they import or export.

The price of tantalite ore peaked in mid-2005 at about 10% more than the pre- and post-peak price after which it remained unchanged until it rose by more than 40% in 2007 compared with the previous 17 months unchanging price when it peaked at yearend. In 2008, the tantalite ore price remained unchanged after declining by 6% from the 2007 yearend peak price. In 2009, the price of tantalite ore continued its decline, decreasing by 22% by yearend to values similar to those reported in early 2007. The price of tantalite ore did not appear to have been driven up in 2008 as those of other metals had been; however, the subsequent decline of metal prices in 2008 and 2009 appeared to have also affected tantalite ore price.

Foreign Trade

Niobium and tantalum material exports from and imports to the United States included ferroniobium and niobium chemicals, metal, ore, and oxide, and tantalum metal and ore. In 2009, the values of foreign trade of these niobium and tantalum materials were $84 million for exports (47% less than that of 2008) and $289 million for imports (45% less than that of 2008).

The United States exported 195 t of niobium contained in niobium materials (79% less than that of 2008) and imported 4,400 t of niobium contained in niobium materials (52% less than that of 2008) (table 1). The United States exported 326 t of tantalum contained in tantalum materials (51% less than that of 2008) and imported 798 t of tantalum contained in tantalum materials (38% less than that of 2008) (table 2).

World Industry Structure

Brazil and Canada were the leading producers of niobium mineral concentrates; Australia, Brazil, Canada, China, and Mozambique were the leading producers of tantalum mineral concentrates. Tantalum-bearing tin slags, which are byproducts from tin smelting, principally from Asia, Australia, and Brazil, are another source of tantalum. The leading niobium ore and concentrate producers were Companhia Brasileira de Metalurgia e Mineração (CBMM) in Brazil and IAMGOLD Corporation (Niobec Mine) in Canada. The leading tantalum ore and concentrate producers were Talison Minerals Pty. Ltd. (Wodgina Mine) in Australia and Metalurg Group (Mibra Mine) and Mineração Taboca S/A (Pitinga Mine) in Brazil. Other tantalum producers were Cabot Corp. (Tanco Mine) in Canada, Noventa Ltd. (Morropino Mine) in Mozambique, and Yichun Tantalum Co., Ltd. (Yichun Mine) in China.

As much as 97% of 2008 world niobium production resulted from the mining pyrochlore mineral [$(Na,Ca)_2Nb_2O_6(OH,F)$] in Brazil and Canada. Steelmaking, primarily high-strength low-alloy and stainless steels, accounted for about 90% niobium use. The niobium-containing high-strength low-alloy steel was use in automobiles, construction, and gas pipelines; the stainless steel in automobiles (Roskill Information Services Ltd., 2009a, p. 1–3).

About 70% of 2008 tantalum world production resulted from the mining of tantalum-containing minerals with an additional 7% from synthetic tantalum ore and the remainder from recycling (Roskill Information Services Ltd., 2009b, p. 8).

The tantalum industry, traditionally shrouded in secrecy, is comprised of (in order of material flow) a mining component that typically extracts ore and produces a concentrate, a processing segment that converts concentrate into an oxide or metal, a parts manufacturing segment that uses the oxide or metal material to produce such components as capacitors or superalloys, and a product manufacturing sector that uses the parts, such as capacitors, in electronic devices, such as cellular telephones (Firman, 2008). World supply by source in 2008 was about 71% from primary production (mining), 20% from recycling, 7% from tin slag, and 2% from inventory (Wallwork, 2008). Tantalum world consumption was estimated to have increased at an average annual rate of 6% from about 1991 through 2006 (Ruffini, 2008).

Tantalum-bearing minerals were considered to be among the "conflict minerals" [minerals identified as a driving force for the conflict in the Congo (Kinshasa)], and production, trade, processing, and use of tantalum has come under international scrutiny (Global Witness Ltd., 2009, p. 4). Transparency of material movement will probably contribute to the reduction of illicit material trade and encourage legitimate mining operations by permitting the tracing and auditing of the supply chain (Ma, 2009). Since those who trade in illicit minerals could reasonably be expected to hide the origin of their material, independent third-party verification is necessary. The Electronic Industry Citizenship Coalition and the Global e-Sustainability Initiative studied the tantalum issue and developed a process to support and promote environmentally and socially responsible practices (Electronic Industries Citizenship Coalition, 2010, p. 21–22; Resolve Inc., 2010, p. 14–19).

World Review

The USGS reported on world niobium-containing carbonatite deposits. USGS reported deposit models and grade and tonnage types based on 58 well-explored and partially mined deposits in several countries. Results were presented as figures showing the cumulative proportion of deposits versus the tonnage or grade of the deposit. About one-half of the 55 carbonatite deposits studied had 0.23% niobium pentoxide (Nb_2O_5) average grade (Berger and others, 2009, p. 14).

Burt (2010) estimated tantalum resources by geographic area, by resource character (known, inferred, or deposit), and by host rock type based on about 100 projects. Bond estimated known resources of 153,000 t of tantalum, of which 44% was in South America, 27% in Australia, 13% in Asia, 12% in Africa, and 5% in North America. Know resources were distributed among in apogranite (61%), carbonatite (7%), pegmatite (25%), and placer (7%) host rock types. Close to 85% of production in 2002 came from pegmatite based ore bodies making them the most significant resource to production. Since they host such a large fraction of resources, apogranite hosted deposits are likely to become more important in the future. No production came from carbonatite deposits. Tantalum resources were found to be abundant and geographically distributed with Australia and Brazil being the leading host countries.

Australia.—The Government of Western Australia reported that tantalite production was 105 t of contained tantalum pentoxide (Ta_2O_5) in 2009 compared with 680 t of contained Ta_2O_5 in 2008 (Government of Western Australia, Department of Mines and Petroleum, 2010, p. 23). Australia reported that, as of December 31, 2008, Joint Ore Reserves Committee (JORC)-compliant proven and probable ore reserves (as stated in company annual reports and reports to the Australian Stock Exchange) for niobium were not available; and for tantalum, 19,000 t of contained Ta_2O_5 (Geoscience Australia, 2009, p. 5).

Talison Minerals Pty. Ltd. suspended production at the Wodgina Mine, the world's leading producing operation of tantalum ore, owing to the global financial downturn and greater market share going to central Africa, where tantalum minerals were mined under conditions of armed conflict and human rights abuses [northeastern regions of Congo (Kinshasa)]. Talison sought to educate consumers about conflict mining and to secure long-term contracts (Emery, 2010, p. 70).

Capital Mining Ltd. (Phillip) reported inferred resources of 55 million metric tons (Mt) containing niobium, among other metals, at a concentration of 80 grams per metric ton (g/t) niobium dioxide (NbO_2) at the Narraburra prospect about 12 kilometers (km) northeast of Temora, New South Wales. Capital received results from gravity separation of drill samples and planned bulk sample treatment (Capital Mining Ltd., 2010, p. 17–18).

Orion Metals Limited (East Brisbane), formerly Queensland Gold and Minerals Ltd., prospected for niobium and tantalum. At Walwa, Orion found 83 parts per million (ppm) Ta_2O_5 and 100 ppm Nb_2O_5 based on rock sampling. Orion drilled at Grants Gully (Orion Metals Limited, 2009).

Galaxy Resources Limited (Perth) prospected for tantalum at Mount Cattlin in Western Australia State near the town of Ravensthorpe. Galaxy reported proved reserves of 2.683 Mt containing 135 ppm Ta_2O_5 and probable reserves of 8.684 Mt containing 151 ppm Ta_2O_5 to a cutoff grade of 0.4% Li_2O. Galaxy reported starting mine development (Galaxy Resources Limited, 2010, p. 2–7).

Brazil.—CBMM mined niobium ore from the Barreiro carbonatite complex (19°40′ S, 46°57′ W) near Araxá, Minas Gerais State, and beneficiated the ore at the mine site by selectively extracting the pyrochlore minerals from which niobium oxide is separated (Filho and others, 2009). The deposit contained 440 Mt of ore reserves at an average grade of 2.5% to 3% Nb_2O_5 that could be mined by open pit methods (Riffel, undated). CBMM produced ferroniobium, nickel-niobium, niobium metal, and high-purity ferroniobium, and had production capacities of 90,000 metric tons per year (t/yr) of ferroniobium, 3,000 t/yr of high-purity ferroniobium and nickel-niobium, and 210 t/yr of niobium metal (Companhia Brasileira de Metalurgia e Mineração, undated a, b). Anglo American Brazil (a subsidiary of Anglo American plc) mined pyrochlore from a carbonatite deposit. Catalão Mine (47°48′ W, 18°08′ S) is comprised of three open pit mines and a processing facility near the city of Catalão, Goiàs State. Anglo reported that Catalão mined 906,700 t of ore and processed 873,500 t of ore containing 9.3 kilograms of niobium per metric ton (kg/t) of ore to produce 5,100 t of contained niobium in 2009. JORC-compliant proved and probable reserves were 12.2 Mt at 1.17% Nb_2O_5 containing 142,000 t of niobium (Anglo American plc, 2010, p. 156, 176).

Mineração Taboca, which was acquired by MINSUR S.A. (Peru), mined columbite at the Pitinga Mine (0°47′01″ N, 60°04′43″ W) in Presidente Figueiredo Municipality, Amazon State. Taboca produced a ferroniobiumtantalum alloy containing 45% niobium, 4.5% tantalum, and 25% iron (Mineração Taboca S/A, undated a, b).

Angel Mining plc (formerly Angus & Ross plc) prospected for tantalum via St. Andrews Mining Ltd., 64% owned by Angel, at the Caiçara project in Rio Grande do Norte State. Angel liquidated St. Andrews' assets paying the former chairman with the company's remaining assets (Angus & Ross plc, 2008, p. 37; Angel Mining plc, 2009, p. 3).

Canada.—Canada reported niobium mine production of 4,330 t of contained Nb_2O_5 and tantalum mine production of 29 t of contained Ta_2O_5 in 2009 compared with 4,400 t of contained Nb_2O_5 and 53 t of contained Ta_2O_5 in 2008. Niobium was produced in Quebec, and tantalum, in Manitoba (Natural Resources Canada, 2009, 2010).

American Manganese Inc. (formerly Rocher Deboule Minerals Corp.) (2010) reported finding no significant niobium value in five holes at two locations on previously untested carbonatite showing about 1 km from the Lonnie carbonatite deposit in British Columbia, where previous exploration had assayed 0.20% Nb_2O_5. Avalon Rare Metals Inc. (Toronto, Ontario) (formerly Avalon Ventures Ltd.) prospected for niobium and tantalum at its Thor Lake (about 62°06′20″ N, 112°36′ W) and Separation Rapids properties. Avalon undertook metallurgical work to recover tantalum and niobium from Thor Lake core samples (Avalon Rare Metals Inc., 2010, p. 3–7).

Commerce Resources Corp. (Vancouver, British Columbia) prospected for niobium and (or) tantalum at the Blue River (east of Quesnel, British Columbia), Eldor (south of Kuujjuaq, Quebec), and Carbo (northeast of Prince George, British Columbia) properties that host carbonatite deposits. Commerce planned an NI 43–101-compliant estimate of Fir, Verity, and Upper Fir deposits, which comprise the Blue River project (Commerce Resources Corp., 2010). Commerce estimated that, at a cutoff grade of 150 g/t tantalum, the Upper Fir deposit contained 8.6 Mt of indicated resources at a grade of 209 g/t Ta_2O_5 and 1,373 g/t Nb_2O_5 content per metric ton of ore and inferred resources of 5.5 Mt at 208 g/t Ta_2O_5 content per metric ton of ore and 1,350 g/t Nb_2O_5 (Gorham, 2007, p. 39).

IAMGOLD mined niobium contained in pyrochlore mineral from the Saint-Honoré carbonatite deposit at the Niobec Mine (about 48°32′ N, 71°09′ W) 15 km northwest of Chicoutimi, Quebec. Niobec mill production capacity was 4,500 t/yr of niobium. The mill produced concentrate, from which Niobec produced Nb_2O_5 that was then converted to standard grade (66% niobium) ferroniobium by aluminothermic reduction. IAMGOLD expected to complete a paste backfill plant and mill expansion in 2010. The mill expansion was to increase throughput by 24%. IAMGOLD reported that niobium mine production in 2009 was 4,100 t of contained niobium compared with 4,400 t in 2008 and 4,300 t in 2007. IAMGOLD reported 32.086 Mt of proven plus probable ore reserves containing 181,300 t of Nb_2O_5 (average ore grade of 0.59% Nb_2O_5). In 2009, Niobec mined 1.773 Mt of ore, milled 1.755 Mt of ore, and produced 4,106 t of niobium (IAMGOLD Corporation, 2010, p. 41, 60, 149).

Tantalum Mining Corp. of Canada Ltd. (near Lac du Bonnet, Manitoba) suspended mine production at its tantalite mine in Manitoba during fiscal year 2009 citing current ore inventory levels and other currently available ore sources as the reason (Cabot Corporation, 2010, p. 6).

Taseko Mines Limited (2009) deferred prospecting for niobium at its Aley prospect owing to economic conditions. Taseko acquired the Aley niobium prospect in northern British Columbia in 2007; however, no mention of the prospect was made in Taseko's annual report (2010a). Taseko identified the Aley niobium property as a key asset (Taseko Mines Limited, 2010b).

Niocan Inc. (2010, p. 6) reported 4.28 Mt of measured resources at an average grade of 0.72% Nb_2O_5 and 6.35 Mt of indicated resources at an average grade of 0.65% Nb_2O_5 based on a cutoff grade of 0.40% Nb_2O_5 at its S–60 niobium deposit near Oka, Quebec.

MDN Inc. (2010b, p. 62–68) completed an NI 43–101-compliant preliminary economic assessment of its Crevier Niobium project north of Lac Saint-Jean, Quebec, and reported that the property (49°30′ N, 72°49′ W) had indicated resources of 25.75 Mt containing 0.186% Nb_2O_5 and 199 ppm Ta_2O_5. MDN estimated a 25-year mine life starting with open pit production followed by underground mining. MDN projected production of 1.133 t/yr of Nb_2O_5 and 220 t/yr of K_2TaF_2 from 1 million metric tons per year (Mt/yr) run-of-mine ore production. MDN planned a feasibility study with the objective of commercializing the niobium and tantalum resource (MDN Inc., 2010a, p. 59).

Sarissa Resources Inc. (2009a) purchased the Nemegosenda property (48°00′ N, 83°06′ W) in Ontario, which was reported to have niobium minerals (Sage, 1987). Sarissa verified that niobium mineralization extended to the east of the Hawke Zone and that a magnetic anomaly was found to the south of what was thought to have been the southern boundary of mineralized zone (Sarissa Resources Inc. 2009b, c).

China.—The leading tantalum mining areas were at Yichun, Jiangxi Province, and Nanping, Fujian Province (Fetherston, 2004, p. 78–79). TiChun Tantalum & Niobium Mine (27°38′58.10″ N, 114°31′4.06″ E) produced tantalum and niobium concentrate (Yichun Tantalum Co., Ltd., undated).

King-Tan Tantalum Industry Co. Ltd. in Shishi Industrial Zone, Yifeng County, Jiangxi Province, produced niobium and tantalum products (King-Tan Tantalum Industry Co. Ltd., undated). Ningxia Non-ferrous Metals Smeltery (a state-owned enterprise) produced niobium and tantalum products (Ningxia Non-ferrous Metals Import & Export Corp., undated).

Congo (Kinshasa).—Katanga, Kivu, Maniema, and Orientale Provinces in the eastern part of Congo (Kinshasa) host columbite-tantalite deposits known locally as coltan (Fetherston, 2004, p. 71). Shamika Resources Inc. (Montreal, Quebec, Canada) prospected for tantalum and niobium through Shamika Congo Kalehe SPRL (Shamika Resources Inc., undated).

Egypt.—Tantalum Egypt JSC [Gippsland Ltd. (Claremont, Australia) and the Government of Egypt] planned to mine tantalite from the Abu Dabbab and Nuweibi deposits. Gippsland reported Abu Dabbab (25°20′59.42″ N, 34°13′30.07″ E) reserves were 15.2 Mt at 260 g/t Ta_2O_5 proven and 15.04 Mt at 250 g/t Ta_2O_5 probable; resources were 15.2 Mt at 290 g/t Ta_2O_5 measured, 17.3 Mt at 250 g/t Ta_2O_5 indicated, and 12 Mt at 200 g/t Ta_2O_5 inferred. At Nuweibi (25°12′3.09″ N, 34°29′56.15″ E), resources were 48 Mt at 147 g/t Ta_2O_5 indicated and 50 Mt at 140 g/t Ta_2O_5 inferred. H.C. Stark Group GmbH (Goslar, Germany) committed to buy 300,000 kg/yr of contained Ta_2O_5 for the first 10 years. Gippsland estimated mine development cost at $175 million and planned to produce a concentrate containing 55% Ta_2O_5. Producing a concentrate reduces transportation cost and limits combined uranium (as U_3O_8) and thorium (as ThO_2) to less than 0.1% (Gippsland Ltd., 2009, p. 7–12).

Gabon.—Eramet Group considered developing the Mabounié deposit (Eramet Group, 2010, p. 70).

Greenland.—The Motzfeldt intrusion, a part of the Igaliko complex of southern Greenland, hosts localized niobium and tantalum mineralization associated with pyrochlore (McCreath, 2009). Ram Resources Limited (Perth, Australia) planned to acquire the Motzfeldt project (near 81°15′ N, 46° W) and to conduct a drilling program there (Fetherston, 2004, p. 69, 71–82; Ram Resources Limited, 2010, p. 1).

Malawi.—Globe Metals & Mining Limited (West Perth, Australia) (2009a, p. 4–10) reported updated resources for the Kanyika Niobium project (about 12°38′ S, 33°38′ E). At a cutoff grade of 0.15% Nb_2O_5, Globe reported JORC-compliant indicated resources of 13.2 Mt containing 48,590 t of Nb_2O_5 (0.36% average grade) and 2,120 t of Ta_2O_5 (0.016% average grade), and inferred resources of 42.1 Mt containing 117,900 t of Nb_2O_5 (0.28% average grade) and 5,470 t Ta_2O_5 (0.013% average grade). Globe planned to improve its resource estimate, to validate a process flowsheet previously developed in a scoping study, and to demonstrate ferroniobium production. Globe (2009b, p. 9, 14, and 16) estimated that for a capital expenditure of $151.7 million it will probably produce 3,000 t/yr of niobium contained in ferroniobium, 194 t of Ta_2O_5, and uranium oxide. Globe and Thuthuka Group Limited (Gauteng, South Africa) (TGL) formed a joint venture to develop the Kanyika property. Globe and TGL planned to develop a bankable feasibility study in support of production planned to start up in 2012 (Thuthuka Group Limited, 2009).

Mozambique.—Noventa Limited (St. Helier, United Kingdom) reported probable reserves of 7.80 Mt containing 2,255 t of Ta_2O_5 at Marropinno (16°30′ S, 37°54′ E) and 3.61 Mt containing 1,673 t of Ta_2O_5 at Morrua (16°16′ S, 37°52′ E) (Noventa Limited, 2007, p. 127–129). Noventa put Marropino Mine, which had been operating intermittently since 2003, on care-and-maintenance status in May and planned to restart production from tailings in 2010 with a modified plant and mine plan. The Marropino Mine was connected to the national power grid. Review of the production process found that process recovery, anticipated to be 60%, was only 30%. It was found that about one-half of the run-of-mine ore was too big to be processed and that the ore size distribution needed to be reduced. A comminution circuit was added to address this problem. Mineralogical, textural, and chemical work showed that recovery could be improved by reducing particle size to less than 1 millimeter and that the tantalum grains do not appear to be included in the mica, permitting the mica to be removed early in the beneficiation process (Noventa Limited, 2010a, p. 8–13; c). Noventa planned to restart production in 2010 (Noventa Limited, 2010b).

Pacific Wildcat Resources Corp. (Canada), a mineral exploration company, acquired Tantalum Mineracao e Prospeccas Limitada, which held licenses for tantalum exploration in the Alto Lingonha belt, Zambezi Provence (about 15°45′10″ S, 33°15′10″ E) near the Muiane Mine, a historical tantalum producer. Pacific also purchased a tantalum treatment plant (Pacific Wildcat Resources Corp., 2010a, b).

Saudi Arabia.—Tertiary Minerals plc planned to evaluate the feasibility of developing the Ghurayyah tantalum-niobium rare-earth deposit subject to receiving a new exploration license that it applied for in 2007 (Tertiary Minerals plc, 2009, p. 2, 5).

Outlook

In a study on emerging-technology driven raw materials demand, raw material production capacity development time was found to be similar to emerging-technology development time permitting raw materials supply development to take place along with emerging-technology development. Market turbulence (that is, price volatility caused by mismatched raw materials supply and demand) was posited to result from the inability of raw materials production capacity development to keep up with emerging-technology demand. This situation resulted from the inability of raw materials producers to identify emerging technologies soon enough and from the lack of information about raw material demand and manufacturing development rates for emerging technologies. Raw materials cost can be the leading cost of manufacturing in industrialized countries that depend on imported raw materials. The authors observed that world economic growth may determine the demand increase for mass-produced raw materials and, at a world economic growth rate of 3.8% per year, consumption of commodities in 2030 would be 2.4 times that of 2006. Tantalum consumption in micro capacitors and medical technology that accounted for 39% of 2006 tantalum production was estimated to increase to 101% of 2006 tantalum production in the year 2030. Niobium consumption in micro capacitors and ferroalloys that accounted for 1% of 2006 niobium production was estimated to increase to 3% of 2006 niobium production in the year 2030 (Angerer and others, 2009).

Niobium.—The principal use for niobium was as an additive in steelmaking, mostly in the manufacture of microalloyed steels. The production of high-strength low-alloy steel was the leading use for niobium, and the trend for niobium consumption, domestically and globally, was expected to continue to closely follow that of steel production, as the steel industry is estimated to account for as much as 90% of niobium consumption. (Additional information about the steel industry can be found in the Iron and Steel chapter of the USGS Minerals Yearbook, volume I, Metals and Minerals.) Consumption of niobium, however, does not mirror trends in overall steel production, as only 10% of steel products contain niobium. The leading nonsteel use of niobium was in superalloys for, among other applications, aircraft engines.

The long-term growth of niobium use was interrupted by the economic downturn of 2008–09. Niobium is used in high-strength low-alloy steels consumed by pipeline, automobile, and construction industries. Greater demand for natural gas was expected to result in increased demand for pipeline steel. The sharp decline in demand for automobiles and in construction that started in 2008 was part of the current economic cycle. Recovery of these markets was expected to revive demand for niobium. It was reported that globally the unit consumption of niobium per metric ton of steel produced was 55 to 60 g/t, while that of highly economically developed countries was 100 g/t and of China was 40 g/t, suggesting significant potential for niobium consumption growth as China's economy develops (Roskill Information Services Ltd., 2009a, p. 124–125).

Tantalum.—Consumers relied heavily on tantalum inventories and huge quantities of highly contentious and politically sensitive, low-cost columbite and tantalite from the Congo (Kinshasa) that appeared to have displaced producers in the conventional supply chain, because an estimated 40% of tantalum mine production was put on care-and-maintenance status in 2008 and 2009 including mines in Australia, Canada, and Mozambique. The mainstream industry sought a way to exclude illegal columbite and tantalite from the supply chain. It was thought that a ban on such material by the United States and the European Union was possible. New production projects in Canada, Egypt, and Saudi Arabia offered the possibility that new mines could be brought into production between 2011 and 2013. It was anticipated that as global economy recovered, so too would demand for tantalum (Roskill Information Services Ltd., 2009b, p. 21–23).

In the midst of consumer industry concern over a possible tantalum shortage that could result from world economic recovery of demand exceeding mine production capacity development, Zogbi (2010) estimated 2009 world tantalum mine production capacity, excluding Australia and Mozambique, to be 727 t/yr of tantalum (equivalent to 845 t/yr of Ta_2O_5, 1,031 t/yr of tantalite) and recycling production to be 544 t/yr of tantalum (equivalent to 633 t/yr of Ta_2O_5, 772 t/yr of tantalite). Australian production capacity was estimated to be 854 t/yr of tantalum (equivalent to 993 t/yr of Ta_2O_5, 1,211 t/yr of tantalite) (Talison Minerals Pty. Ltd., 2007), and Mozambican, 83 t/yr of tantalum (equivalent to 96 t/yr of Ta_2O_5, 117 t/yr of tantalite) (Noventa Limited, 2010a, p. 12). Based on these estimates, 2009 world tantalum production capacity was about 3,590 t/yr of tantalum, while projected 2009 demand was 2,460 t of tantalum based on 4% annual growth rate from 2006, which was enough production capacity to meet demand with Australian production closed as was the situation. World demand for 2013 was projected to be 2,900 t of tantalum, an amount that could be met from 2009 mine and recycling production capacity.

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TABLE 1

SALIENT NIOBIUM STATISTICS[1]

		2005	2006	2007	2008	2009[e]
United States:						
Government stockpile releases, Nb content[2, 3]	metric tons	152	156	--	--	--
Exports, Nb content[4]	do.	337	561	1,100	781	195
Imports for consumption:						
Mineral concentrates, Nb content	do.	142	120	109	134	41
Niobium metal, gross weight[5]	do.	1,380	1,450	864	1,130	699
Niobium oxide, Nb content[e]	do.	661	760	744	852	742
Ferroniobium, Nb content[e]	do.	5,430	8,150	8,400	7,120	2,920
Reported consumption, Nb content						
Raw materials	do.	W	W	W	W	W
Ferroniobium and nickel niobium[e]	do.	4,600	5,050	6,510	5,380 [r]	4,350
Apparent consumption, Nb content	do.	7,430	10,100	9,020	8,450	4,210
Price,[6] ferroniobium[7] Nb content	dollars per kilogram	14.5	NA	NA	NA	NA
Value:[8]						
Niobium ores and concentrates (gross weight)	do.	9.70	13.71	22.55	26.70	59.86
Niobium oxide (gross weight)	do.	14.12	14.07	17.64	25.65	27.30
Ferroniobium (gross weight)	do.	8.66	9.13	13.88	21.29	23.59
World, production of niobium-tantalum concentrates, Nb content	metric tons	43,100 [r]	52,800 [r]	62,000 [r]	63,000 [r]	62,900 [e]

[e]Estimated. [r]Revised. do. Ditto. NA Not available. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Release is the decrease of uncommitted inventory relative to the previous calendar year.

[3] To estimate Nb content, it was assumed that natural tantalum and synthetic tantalum-niobium ores and concentrates are 16% niobium pentoxide (Nb_2O_5); niobium ores and concentrates are 30% Nb_2O_5; and Nb_2O_5 is 69.9% Nb.

[4] Includes natural and synthetic niobium ore and concentrates, niobium oxide, niobium ferroalloy, and unwrought niobium metal and alloys.

[5] Includes niobium and articles made of niobium.

[6] The published price for columbite ore was discontinued in 2001 at a range of $5.50 to $7.00 per pound of Nb_2O_5 content. The published prices of Brazilian and Canadian pyrochlore were discontinued in 1981 and 1989, respectively. Price is time-weighted average as reported in trade journals.

[7] Standard (steelmaking) grade. American Metal Market discontinued reporting the price of vacuum-grade ferroniobium in 2002 and standard grade in 2005.

[8] Mass-weighted average value of imported plus exported materials.

TABLE 2

SALIENT TANTALUM STATISTICS

		2005	2006	2007	2008	2009[e]
United States:						
Government stockpile releases,[1] Ta content[2]	metric tons	210	289	--	--	--
Exports:						
Tantalum ores and concentrates,[3] Ta content	do.	174	247	146	96	94
Tantalum metal, gross weight	do.	567	590	207	390	138
Tantalum and tantalum alloy powder, gross weight	do.	242	112	158	176	94
Imports for consumption:						
Mineral ores and concentrates, Ta content	do.	382	322	294	357	109
Tantalum metal and tantalum-bearing alloys,[4] gross weight	do.	1,240	835	861	934	689
Tin slag	do.	NA	NA	NA	NA	NA
Reported consumption, raw materials Ta content	do.	W	W	W	W	W
Apparent consumption, Ta content	do.	852	498	644	629	473
Price, tantalite,[5] Ta_2O_5 content	dollars per kilogram	77	72	80	87	60
Value,[6] tantalum ores and concentrates, gross weight	do.	31	33	43	49	38
World, production of niobium-tantalum concentrates, Ta content	metric tons	1,380 [r]	867 [r]	994 [r]	1,190 [r]	665

See footnotes at end of table.

TABLE 2—Continued
SALIENT TANTALUM STATISTICS

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[e] Estimated. do. Ditto. NA Not available. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Release is the decrease in uncommitted inventory relative to the previous calendar year.

[2] To estimate Ta content, it was assumed that natural niobium and synthetic niobium-tantalum ores and concentrates are 32% Ta_2O_5; tantalum ores and concentrates are 37% Ta_2O_5; and Ta_2O_5 is 81.9% tantalum.

[3] Includes natural and synthetic tantalum ore and concentrates.

[4] Includes unwrought powders, unwrought alloys and metals, waste and scrap, and wrought alloys and metal.

[5] Time-weighted average price per Ta_2O_5 content as reported in trade journals. Includes Platts Metals Week and Ryan's Notes.

[6] Mass-weighted average value of imported plus exported materials.

TABLE 3
REPORTED CONSUMPTION, BY END USE, INDUSTRY STOCKS OF FERRONIOBIUM AND NICKEL NIOBIUM AND GOVERNMENT STOCKS BY MATERIAL IN THE UNITED STATES[1]

(Metric tons of niobium and tantalum content)

	2008	2009
End use:		
Steel:		
Carbon	1,450	970
Stainless and heat-resisting	674	551
Full alloy	(2)	(2)
High-strength low-alloy	852	651
Electric	(2)	(2)
Tool	(2)	(2)
Unspecified	1,010 r	1,030
Total	3,990 r	3,200
Superalloys	1,380 r	1,130
Alloys (excluding steels and superalloys)	16	21
Miscellaneous and unspecified	--	--
Grand total	5,380 r	4,350
Stocks, December 31:		
Consumer	341 r	321
Producer[3]	W	W
Total	341 r	321
National Defense Stockpile, total uncommitted inventory by material:		
Niobium metal ingots	10.0	10.0
Tantalum carbide powder	1.72	1.72

[r] Revised. W Withheld to avoid disclosing company proprietary; data not included in total. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Included with "Steel, unspecified."

[3] Ferroniobium only.

TABLE 4

U.S. FOREIGN TRADE IN NIOBIUM AND TANTALUM METAL AND ALLOYS, BY CLASS[1]

HTS code[2]	Class	2008 Gross mass (kilograms)	2008 Value (thousands)	2009 Gross mass (kilograms)	2009 Value (thousands)	Principal destinations and sources in 2009 (gross mass in kilograms and values in thousand dollars)
	Exports:					
	Niobium:					
2615.90.6030	Ores and concentrates	62,800	$2,010	17,000	$954	Sweden 11,400, $778; Argentina 2,140, $104; United Kingdom 1,960, $42; Austria 778, $5; Italy 399, $3; Canada 308, $15; China 2, $6.
7202.93.0000	Ferroniobium	1,130,000	12,500	240,000	2,740	Mexico 127,000, $1,400; Canada 98,200, $1,180; Republic of Korea, 12,700, $140; Philippines 1,150, $15; New Zealand 200, $4.
	Tantalum:					
2615.90.3000	Synthetic concentrates	110,000	302	158,000	796	China 119,000, $436; Brazil 19,400, $56; Ireland 17,800, $277; United Kingdom 1,090, $10; France 811, $7; Switzerland 24, $10.
2615.90.6060	Ores and concentrates	167,000	2,490	160,000	2,110	Brazil 109,000, $524; Japan 32,900, $1,270; China 15,900, $219; United Kingdom 1,650, $80; France 283, $6; Costa Rica 9, $4.
8103.20.0030	Unwrought, powders	176,000	64,600	93,800	40,200	Mexico 42,600, $17,600; Germany 25,900, $14,100; Israel 19,500, $6,240; Sweden 2,200, $347; Japan 1,280, $755; Portugal 1,230, $704; Austria 419, $77; Thailand 272, $106; China 205, $89; Czech Republic 96, $51; Singapore 27, $14; Italy 10, $3; United Kingdom 5, $7; Norway 4, $19.
8103.20.0090	Unwrought, alloys and metal	39,000	4,390	6,760	1,030	Malaysia 3,620, $615; Germany 1,400, $5; United Kingdom 1,060, $181; Canada 620, $144; Singapore 37, $16; China 12, $6; Italy 11, $4; Republic of Korea, 4, $5; France 2, $3.
8103.30.0000	Waste and scrap	247,000	20,800	79,000	8,930	United Kingdom 18,700, $2,520; China 13,000, $1,130; Netherlands 10,000, $1,180; Estonia 8,100, $990; Hong Kong 6,710, $458; Australia 4,480, $879; Kazakhstan 4,280, $267; Germany 3,900, $419; Austria 3,770, $412; Canada 2,460, $208; Malaysia 1,570, $327; Thailand 1,000, $69; Republic of Korea, 571, $50.
8103.90.0000	Wrought	104,000	49,300	52,200	26,900	Mexico 19,900, $10,700; Japan 11,800, $4,690; Germany 9,470, $4,430; France 2,670, $1,260; United Kingdom 2,070, $1,030; Republic of Korea, 1,360, $1,370; Czech Republic 1,050, $716; Israel 826, $725; Malaysia 627, $363; Italy 589, $332; Taiwan 514, $169; Canada 404, $202; China 258, $328; Switzerland 214, $158.
	Total	XX	156,000	XX	83,600	
	Imports for consumption:					
	Niobium:					
2615.90.6030	Ores and concentrates	15,600	$87	4,960	$360	China 4,930, $357; Netherlands 33, $4.
2825.90.1500	Oxide	1,220,000	31,300	1,060,000	29,000	Brazil 909,000, $23,200; China 57,700, $2,320; Germany 50,000, $2,650; Russia 45,000, $801; United Kingdom 23, $9.

See footnotes at end of table.

TABLE 4—Continued
U.S. FOREIGN TRADE IN NIOBIUM AND TANTALUM METAL AND ALLOYS, BY CLASS[1]

HTS code[2]	Class	2008 Gross mass (kilograms)	2008 Value (thousands)	2009 Gross mass (kilograms)	2009 Value (thousands)	Principal destinations and sources in 2009 (gross mass in kilograms and values in thousand dollars)
	Imports for consumption—Continued:					
	Niobium—Continued:					
	Ferroniobium:					
7202.93.4000	Silicon < 0.4%	258,000	8,290	151,000	5,080	Brazil 137,000, $4,560; Germany 12,100, $453; United Kingdom 2,040, $65.
7202.93.8000	Other	10,700,000	237,000	4,340,000	104,000	Brazil 2,950,000, $70,300; Canada 1,380,000, $33,400; Germany 1,500, $41.
	Total	11,000,000	245,000	4,490,000	109,000	
8112.92.4000	Unwrought, and powder[3]	1,130,000	47,500	699,000	24,100	Brazil 638,000, $21,700; Germany 36,500, $1,100; Estonia 14,300, $778; Russia 7,350, $165; China 1,020, $192; Japan 894, $48; Thailand 394, $79; Austria 75, $14; Hong Kong 43, $5.
	Tantalum:					
2615.90.3000	Synthetic concentrates	3,620	21	546	27	All From China.
2615.90.6060	Ores and concentrates	1,160,000	63,100	356,000	13,500	Mozambique 174,000, $5,470; Canada 116,000, $4,760; Australia 65,000, $3,260; China 855, $55,600; United Kingdom 23, $4.
8103.20.0030	Unwrought powders	230,000	52,800	139,000	39,500	China 73,600, $16,600; Japan 40,300, $16,100; Germany 19,400, $4,880; Thailand 3,140, $1,040; Kazakshtan 1,980, $410; Portugal 1,020, $408; Georgia 50, $11; Mexico 25, $9; Netherlands 5, $2.
8103.20.0090	Unwrought, alloys and metal	194,000	34,600	138,000	29,600	Kazakhstan 88,200, $20,200; China 40,000, $7,490; Germany 9,650, $1,580; Japan 330, $54; Netherlands 244, $33; United Kingdom 61, $49; Liechtenstein 19, $36.
8103.30.0000	Waste and scrap	410,000	26,000	335,000	23,800	China 83,200, $2,770; Estonia 59,900, $10,700; Austria 50,600, $2,890; Japan 36,800, $1,880; Portugal 32,100, $1,190; Germany 22,500, $437; France 11,800, $151; Hong Kong 11,500, $702; United Kingdom 7,530, $1,150.
8103.90.0000	Wrought	101,000	23,200	75,600	20,800	China 63,000, $14,700; Kazakhstan 5,750, $1,440; Austria 3,300, $2,200; Germany 2,130, $1,680; France 589, $150; Switzerland 230, $16; Denmark 206, $130; Singapore 134, $14; Japan 81, $228.
	Total	XX	524,000	XX	289,000	

XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

[3] Niobium waste and scrap is included in 8112.92.0600 along with other materials. Niobium other than unwrought; waste and scrap; and powders are included in 8112.99.9000 along with other materials.

Sources: U.S. Census Bureau and U.S. Geological Survey.

TABLE 5
U.S IMPORTS FOR CONSUMPTION OF TANTALUM ORES AND CONCENTRATES, BY COUNTRY[1]

	2008		2009	
Country	Gross mass (kilograms)	Value (thousands)	Gross mass (kilograms)	Value (thousands)
Australia	774,000	$49,900	65,000	$3,260
Canada	193,000	7,340	116,000	4,760
China	9,900	653	855	56
France	64	3	--	--
Mozambique	179,000	5,000	174,000	5,470
Nigeria	6,110	206	--	--
United Kingdom	--	--	23	4
Total	1,160,000	63,100	356,000	13,500

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Sources: U.S. Census Bureau and U.S. Geological Survey.

TABLE 6

NIOBIUM AND TANTALUM: WORLD PRODUCTION OF MINERAL CONCENTRATES, BY COUNTRY[1, 2]

(Metric tons)

Country[5]	Gross mass[3]					Niobium content[4]					Tantalum content[4]				
	2005	2006	2007	2008	2009 e	2005	2006	2007	2008	2009 e	2005	2006	2007	2008	2009 e
Australia, columbite-tantalite[6]	3,820 e	2,140 e	1,630 e	2,060 e	318	--	--	--	--	--	854	478	441	557	81 [7]
Brazil:															
Nb minerals[8, 9]	247,023	206,550	245,766	246,000	247,000 p	39,162	48,129	57,267	58,000 e	58,000	--	--	--	--	--
Ta minerals[e, 6, 10]	792	645	650	650	650	--	--	--	--	--	216 [7]	176 [7]	180	180	180
Burundi	43	16	52	84 r	84	8	3	10 r	16 r	16	9	3	9	16 r	16
Canada:															
Nb minerals[9]	11,100 e	12,500 e	12,900 e	13,150	12,900	3,710	4,157	4,337	4,383	4,330 [7]	--	--	--	--	--
Ta minerals[6, 10]	282	249	201	150	110	--	--	--	--	--	63	56	45	40	25
Congo, (Kinshasa):															
Columbite-tantalite[e, 11]	124 [7]	52 [7]	267 [7]	380	330	28	12	61	86	75	33	14	71	100	87
Nb minerals	--	--	--	240 e	180	--	--	--	120 e	90	--	--	--	--	--
Ethiopia, tantalite	93	109	117 r	83 r	83	9	11	12	8 r	8	49 r	57 r	52 r	37 r	37
Mozambique[e]	281 [7]	95 r, 7	196	396 r, 7	405 [7]	20 r	7 r	14 r	28 r	29	81	27 r	56 r	110 r	113
Nigeria, columbite-tantalite[e]	110	900	450	500	450	45 [7]	387 [7]	180 [7]	194 [7]	180	5	10	20	25	20
Rwanda	276	188	490	490	430	87 r	59 r	150 r	150 [7]	130	68 r	46 r	120 r	120 r	104
Somalia[12]	--	--	--	11 e	7	--	--	--	2 e	2	--	--	--	3 e	2
Uganda[e]	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)
Zimbabwe[e]	--	NA	--	--	--	--	--	--	--	--	--	NA	--	--	--
Total	264,000	223,000	263,000	264,000	263,000	43,100	52,800	62,000	63,000	62,900	1,380	870 r	872 r	1,190 r	670

e Estimated. p Preliminary. r Revised. NA Not available. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes production of niobium and tantalum contained in tin ores and slags. Table includes data available through July 5, 2010.

[3] Gross mass is mass of concentrate before metal is extracted.

[4] Content is mass of metal produced. Nb_2O_5 is 69.904% niobium; Ta_2O_5 is 81.897% tantalum.

[5] In addition to the countries listed, Bolivia, China, French Guiana, Kazakhstan, and Russia also produce, or are thought to produce, niobium and tantalum mineral concentrates, but available information is inadequate to make reliable estimates of output levels.

[6] Tantalum production reported in Ta_2O_5 converted to tantalum content. Gross mass is concentrate assumed to be one-third Ta_2O_5.

[7] Reported figure.

[8] Niobium concentrate production reported in Nb_2O_5 content converted to niobium content. Gross mass is concentrate assumed to be one-third Nb_2O_5.

[9] Includes columbite and pyrochlore.

[10] Includes djalmaite and tantalite.

[11] Reported data includes the North and South Kivu Provinces.

[12] From August 2008 to April 2009, 18 metric tons of columbite-tantalite were reportedly produced in Somalia. It is unclear if production continued after early April 2009.

[13] Less than ½ unit.

TABLE 7

FERRONIOBIUM (FERROCOLUMBIUM): WORLD PRODUCTION, BY COUNTRY[1]

(Metric tons, Nb content)

Country[2]	2005	2006	2007	2008	2009[e]
Brazil	25,621 [r]	27,434 [r]	34,612 [r]	25,403 [r]	25,410 [p, 3]
Canada	3,710	4,157 [r]	4,337	4,385	3,960
India[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
Russia[e]	--	--	80	80	79
United States	NA	NA	NA	NA	NA
Total	29,300 [r]	31,600 [r]	39,000 [r]	29,900 [r]	29,400

[e]Estimated; estimated data are rounded to no more than three significant digits; may not add to totals shown. [p]Preliminary. [r]Revised. NA Not available. -- Zero.

[1] Table includes data available through August 20, 2010.

[2] In addition to the countries listed, Austria, China, and Germany are thought to have produced ferroniobium (ferrocolumbium), but production information is inadequate for the formulation of estimates of output levels.

[3] Reported figure.

NITROGEN

By Lori E. Apodaca

The world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2009, U.S. ammonia production contained 7.70 million metric tons (Mt) of nitrogen, a slight decrease from production in 2008, and apparent consumption decreased by about 9% from that in 2008. Exports of ammonia were significantly lower than those in 2008. Imports decreased by about 25% compared with those of 2008. Most of the imports in 2009 were from Canada, Russia, and Trinidad and Tobago. About 84% of the domestically produced ammonia consumed in the United States was used in fertilizer applications. Global ammonia production in 2009, which was estimated to contain 130 Mt of nitrogen, was the same as in 2008. China, India, Russia, and the United States were the leading producers, together accounting for about 55% of the total.

Legislation and Government Programs

The U.S. Environmental Protection Agency (EPA) was proposing revisions to the National Renewable Fuel Standard (RFS) program that would shift U.S. ethanol production away from its reliance on corn. Existing ethanol production would be grandfathered in under the proposed rules, but EPA wanted to boost consumption of cellulose and other sources of renewable fuel in response to the Energy Independence and Security Act (EISA) of 2007. EISA established specific volume standards for advanced biofuel, biomass-based diesel, cellulosic biofuel, and total renewable fuel that must be used in transportation fuel each year (Fertilizer Week, 2009f).

The National Association of Wheat Growers, the Agricultural Retailers Association, and others requested that the U.S. Department of Commerce remove trade restrictions that are in place against ammonium nitrate from Russia. The reason for removing trade restrictions was that many domestic manufacturers and distributors have ceased production and sales of ammonium nitrate for liability and safety reasons. As a result, in periods of high ammonium nitrate demand in the United States, agricultural retailers, distributors, and farmers must pay a higher price for the product (Green Markets, 2009c).

Production

Industry statistics for anhydrous ammonia and derivative products were developed by the U.S. Census Bureau. A summary of the production of principal inorganic fertilizers by quarter was reported in the series MQ325B. In 2009, production of anhydrous ammonia (82.2% nitrogen) decreased slightly to 7.70 Mt of contained nitrogen compared with a revised figure of 7.87 Mt in 2008 (table 1). Of the total production, 84% was for use as a fertilizer; the remaining 16% was used in other chemical and industrial sectors (table 2).

The United States was a leading producer and consumer of elemental and fixed types of nitrogen. In declining order, urea, ammonium nitrate, ammonium phosphates [diammonium phosphate (DAP) and monoammonium phosphate (MAP)], nitric acid, and ammonium sulfate were the major downstream products derived from domestic and imported ammonia in the United States. Their combined production was 8.07 Mt of contained nitrogen, with urea accounting for 29% of the total, ammonium nitrate accounting for 26% of the total, and ammonium phosphates and nitric acid accounting for 23% and 16%, respectively, of the production (table 3).

Ammonia producers in the United States operated only at about 72% of design capacity in 2009; this percentage included capacities at plants that operated during any part of the year and did not include plants that were idle for all of 2009. Of the total available U.S. ammonia production capacity, more than 59% was concentrated in the States of Louisiana (35%), Oklahoma (19%), and Texas (5%), where there are large reserves of feedstock natural gas. Koch Nitrogen Co., LLC, Terra Industries Inc., PCS Nitrogen, Inc., CF Industries Holdings, Inc., and Agrium Inc., in descending order, accounted for 79% of total U.S. ammonia production capacity (table 4).

Beginning in 2009, CF Industries' board of directors approved and proposed the acquisition of all the outstanding common shares of Terra Industries Inc. and submitted a merger proposal to Terra Industries. The CF Industries and Terra Industries merger would have the capacity to produce 5.7 Mt of nitrogen and 2.1 Mt of phosphates and would account for about 16% of North American fertilizer capacity. Terra Industries was a nitrogen producer and had no phosphate capability. In February, Agrium sought to buy CF Industries to boost its capacity to make nitrogen-based crop nutrients, while CF Industries was attempting to acquire Terra Industries (Fertilizer Week, 2009d). At yearend, CF Industries was still in negotiations to acquire Terra Industries, and Agrium remained interested in acquiring CF Industries.

In February, The Mosaic Co. restarted its Faustina, LA, ammonia complex, which had been shut down in late 2008 as a result of the economic slowdown. The plant had the capacity to produce 508,000 metric tons per year (t/yr) of anhydrous ammonia (Fertilizer Week, 2009q).

Agrium's Borger, TX, nitrogen plant resumed production in February. The Borger plant had the capacity to produce 490,000 t/yr of ammonia and 99,000 t/yr of urea (Green Markets, 2009f).

Terra Industries resumed production in February at its Woodward, OK, facility after the plant was idled in December 2008. The Woodward facility had the capability to produce 399,000 t/yr of ammonia with about 277,000 t/yr sold as a finished product (Terra Industries Inc., 2009).

Koch Nitrogen completed enhancements to its Enid, OK, facility to increase urea production. The project provided an additional estimated 127,000 t/yr of urea capacity and significantly enhanced the plant's rail load out capability (Koch Nitrogen Co., LLC, 2009).

Terra Industries restarted its 454,000-t/yr Donaldsonville, LA, ammonia plant in April as market conditions improved

(Nitrogen + Syngas, 2009f). However, on July 1, Terra Industries again idled the plant owing to a decrease in industrial demand, the end of the spring agricultural season, and lower ammonia prices (Green Markets, 2009g).

Eastman Chemical Co. discontinued its $1.6 billion Beaumont, TX, industrial gasification project. Several factors contributed to this decision, which included high capital costs, current and projected decrease in the spread between natural gas, oil, and petroleum coke prices, and the continued uncertainty in U.S. energy and environmental public policy. The petroleum coke-based gasification plant would have helped run the idled anhydrous ammonia (231,000 t/yr production capacity) and methanol units that Eastman had purchased from Terra Industries in 2007 (Green Markets, 2009b).

LSB Industries, Inc. experienced many startup delays at its Pryor, OK, urea ammonia nitrate plant in 2009. In January 2010, LSB Industries began production of anhydrous ammonia but at production rates much lower than the targeted rates. The Pryor facility was expected to produce and sell approximately 295,000 t/yr of urea and 32,000 t/yr of anhydrous ammonia when fully operational (LSB Industries Inc., 2009, 2010).

Southeast Idaho Energy LLC was issued a revised air quality permit that imposed new limits on CO_2 emissions for its proposed $1.5 billion nitrogen facility near American Falls, ID. The nitrogen plant, using advanced clean-coal gasification technology, would produce 453 metric tons per day (t/d) of anhydrous ammonia, 1,630 t/d of granular urea, and 1,450 t/d of UAN. Construction of the plant was anticipated to begin in 2011 (Green Markets, 2009h).

SynGest Inc. planned to build a $102 million corn-based anhydrous ammonia plant near Menlo, IA. The plant was expected to use about 118,000 t/yr of corn cobs to produce 45,000 t/yr of ammonia. Plant construction was anticipated to start in the first half of 2010 (Green Markets, 2009d).

Environment

Hypoxia has become a controversial environmental concern for the fertilizer industry and an issue that spawned significant research efforts to determine its cause. Hypoxia happens where water near the bottom of an affected area in a large body of water, such as the Gulf of Mexico, contains less than 2 parts per million of dissolved oxygen. Hypoxia can cause stress or death in bottom-dwelling organisms that cannot move out of the hypoxic or “dead” zone.

Dead zones in coastal oceans have been reported in more than 400 ecosystems, affecting a total area of more than 245,000 square kilometers worldwide. The number of dead zones has approximately doubled each decade since the 1960s. More recently, dead zones have developed in continental seas, such as the Baltic Sea, the Black Sea, the East China Sea, the Gulf of Mexico, and the Kattegat (Diaz and Rosenberg, 2008).

In January, the Gulf of Mexico Hypoxia Monitoring Implementation Plan was completed. The plan provided a multistep, tiered approach to improve monitoring of the Gulf of Mexico in support of the 2008 Gulf Hypoxia Action plan. Included in the plan were detailed core monitoring system requirements, details for expanded observing systems, and needs for advancing the understanding of hypoxia causes and impacts. Also provided were specific directions for improved data availability and outreach. Several Federal and State partners have committed to implementing many of the system requirements of the plan (Gulf of Mexico Hypoxia Monitoring Implementation Plan Steering Committee, 2009, p. 9).

U.S. Department of Agriculture (USDA) announced an initiative to improve water quality and the overall health of the Mississippi River Basin. The Mississippi River Basin Healthy Watersheds Initiative (MRBI) would provide approximately $320 million during the next 4 years to projects in priority watersheds located in Arkansas, Kentucky, Illinois, Indiana, Iowa, Louisiana, Minnesota, Mississippi, Missouri, Ohio, Tennessee, and Wisconsin. The goal of the MRBI was to help farmers and landowners implement conservation practices that would avoid, control, and trap nutrient runoff. Participation in the initiative, which was managed by USDA’s Natural Resources Conservation Service and funded by the Cooperative Conservation Partnership Initiative and other Farm Bill Conservation Title programs, would be made available through a competitive process for potential partners at the local, State, and national levels (Green Markets, 2009i).

Consumption

In 2009, apparent consumption of ammonia was 12.3 Mt of contained nitrogen, about 9% lower than that in 2008. Apparent consumption is calculated as production plus imports minus exports, adjusted to reflect any changes in stocks. Consumption of nitrogen fertilizers in the United States for the 2009 crop year (ending June 30, 2009) is listed in table 5. Consumption was estimated to be 11.6 Mt of contained nitrogen, which was slightly higher than that of 2008. Anhydrous ammonia and nitrogen solutions, mostly UAN solutions containing 29.8% to 29.9% nitrogen, were the principal fertilizer products, representing 30% and 25%, respectively, of fertilizer consumption. Urea (45.9% nitrogen) constituted 20% of fertilizer consumption during the 2009 crop year. Ammonium nitrate (33.9% nitrogen) and ammonium sulfate each constituted 2% of 2009 nitrogen fertilizer consumption. The leading nitrogen-consuming States in the 2009 crop year were California, Iowa, Illinois, Kansas, and Nebraska.

Stocks

Stocks of ammonia at yearend 2009 were 167,000 metric tons (t), a decrease of 45% from comparable revised stocks at yearend 2008, according to data published by the U.S. Census Bureau (table 6).

Transportation

Ammonia was transported by refrigerated barge, rail car, pipeline, and tank truck. Three companies served 11 States with 5,090 kilometers (km) of pipelines and 4,800 km of river barge transport; rail and truck were used primarily for interstate or local delivery.

NuStar Energy L.P. continued to operate the Gulf Central ammonia pipeline. The 3,200-km ammonia pipeline originated in the Louisiana Delta area, where it had access to three marine terminals and three anhydrous ammonia plants on the

Mississippi River. The capacity of this pipeline was about 2 million metric tons per year (Mt/yr) of ammonia, with a storage capacity of more than 1 Mt. In 2009, about 1.1 Mt of ammonia was shipped through the Gulf Central ammonia pipeline (NuStar Energy L.P., 2010, p. 13).

Magellan Midstream Partners, L.P. owned a common carrier ammonia pipeline system. The 1,750-km pipeline system, which transported and distributed ammonia from production facilities in Oklahoma and Texas to various distribution plants in the Midwest, had a delivery capacity of about 820,000 t/yr. In 2009, 583,000 t of ammonia was shipped through Magellan's pipeline compared with 746,000 t in 2008 (Magellan Midstream Partners L.P., 2010, p. 34). Tampa Pipeline Corp. operated the 135-km Tampa Bay Pipeline system, which moved ammonium phosphate and nitrogen compounds for fertilizer producers in Hillsborough and Polk Counties, FL.

Prices

Midyear and yearend prices for nitrogen materials are listed in table 7. The average gulf coast ammonia price began 2009 at $120 per short ton ($132 per metric ton), and in September reached the high for the year of $325 per short ton ($358 per metric ton), where it remained until early November. At yearend, the ammonia price was $275 per short ton ($303 per metric ton), a 15% decrease in price from the average high for 2009.

The average granular urea price fluctuated throughout 2009, beginning the year at $215 per short ton ($237 per metric ton). The average price reached a high of $318 per short ton ($351 per metric ton) at the beginning of December. At yearend, the urea price was $311 per short ton ($343 per metric ton).

The average ammonium nitrate price, which began 2009 at $275 per short ton ($303 per metric ton), remained fairly consistent throughout the year. The average price rose to $318 per short ton ($351 per metric ton) by early July and then decreased to $268 per short ton ($295 per metric ton) by yearend.

Typically, ammonium sulfate prices do not follow the same trend as other nitrogen products, which correlate to natural gas prices, mainly because a substantial portion of the material is produced as a byproduct of caprolactam production. Caprolactam, an organic compound, is the precursor to Nylon 6, a widely used synthetic polymer. The average price began 2009 at about $205 per short ton ($226 per metric ton) and fluctuated, reaching a high of $235 per short ton ($259 per metric ton) in mid-March and remaining at this level through June. By yearend, the price reached an average of $198 per short ton ($218 per metric ton).

In 2009, the annual average prices paid for fertilizers decreased by about 30%. One reason for the decline in fertilizer prices was that the annual average cost of natural gas, the primary feedstock for nitrogen fertilizers, was down 54% in 2009 compared with the annual average in 2008 (U.S. Department of Agriculture, Economic Research Service, 2010a).

Foreign Trade

Ammonia exports were about 91% lower than those in 2008 (table 8). Canada was the leading destination for U.S. exports of ammonia; the total quantity exported to Canada decreased by 93% from that in 2008. Canada represented the destination for 75% of total U.S. exports of ammonia in 2009.

Ammonia imports were about 25% lower than those in 2008 and dwarfed the quantity of exports. The average value of ammonia imports decreased to $285 per metric ton from $597 per metric ton in 2008 (table 9). Trinidad and Tobago (68%) continued to be the leading import source. Canada (15%) and Russia (8%) were the remaining significant import sources.

Tables 10 and 11 list trade data for other nitrogen materials and include information on principal destination or source countries. Exports of nitrogen materials decreased in 2009, with the exception of ammonium nitrate and DAP. Import quantities of nitrogen materials were lower than imports in 2008 for most nitrogen compounds. The exceptions were ammonium nitrate and limestone mixtures and potassium nitrate and sodium nitrate mixtures.

World Review

Anhydrous ammonia and other nitrogen materials were produced in more than 70 countries. Global ammonia production in 2009, estimated to be 130 Mt, was about the same as that in 2008 (table 12). China, with 33% of total production, was the leading world producer of ammonia. Asia contributed 49% of total world ammonia production, and the Commonwealth of Independent States (CIS), Estonia, and Lithuania produced 14% of the global total. North America represented 9% of the total; Middle East and Western Europe, 7% each; Central America and South America together, 6%; and Africa, Eastern Europe, and Oceania together contributed the remaining 8%.

In 2009, world ammonia exports, estimated to be 14.4 Mt of contained nitrogen, were lower than those in 2008. Canada, Indonesia, Russia, Saudi Arabia, and Trinidad and Tobago accounted for about 66% of the world export total. North America (primarily the United States) imported 32% of global ammonia import trade, followed by Asia (27%) and Western Europe (19%) (International Fertilizer Industry Association, 2010).

European Union.—At the request of the European Fertilizer Manufacturers Association (EFMA) on behalf of the Community Ammonium Nitrate industry, the European Union (EU) opened a review investigation into the dumping of ammonium nitrate imports from Ukraine in April. EFMA supplied evidence to show that there was continued dumping activity by Ukraine and that there was a likelihood of the recurrence of dumping if the existing measures were allowed to lapse. The antidumping duty amounted to $46 per metric ton. The ammonium nitrate restrictions were first imposed in 2001 (Fertilizer Week, 2009j).

Algeria.—Sorfert Algerie (a joint venture between Orascom Construction Industries and Sonatrach) reported that construction on the ammonia and urea plant at Arzew was on track for commissioning during late 2010. The plant would have a production capacity of 800,000 t/yr of ammonia and 1.2 Mt/yr of urea. Most, if not all, of the output would be targeted toward the export market (Fertilizer Week, 2009p).

Australia.—Perdaman Chemicals and Fertilisers Pty. Ltd. announced plans to build a $2.8 billion urea manufacturing facility in Collie, about 200 km south of Perth, Western Australia. The plant would use gasification technologies to turn subbituminous coal into 1.6 Mt/yr of ammonia and 2 Mt/yr of urea. The first shipment of urea was expected by 2013. The plant would be built in a new 246-hectare industrial park recently opened by the Western Australian state government (Nitrogen + Syngas, 2009a). Denmark's Haldor Topsøe A/S was providing the ammonia synthesis technology, and Netherlands-based Stamicarbon B.V. would supply the urea melt and granulation technology for the plant. Royal Dutch Shell plc would provide the coal gasification technology for the new facility. The urea produced would be targeted primarily toward the export market (Fertilizer Week, 2009n).

Brazil.—Petróleo Brasiliero S.A. (Petrobras) planned to locate its proposed ammonia and urea plant at Tres Lagoas in Mato Grosso do Sul State. The production capacity of the plant would be 760,000 t/yr of ammonia and 1 Mt/yr of urea. Cost for the plant was estimated to be $1.5 billion. The plant was expected to be completed by 2013 (Fertilizer Week, 2009m).

Canada.—In January, Agrium announced the restart of its Fort Saskatchewan, Alberta, nitrogen facility and resumption of urea production at its other Canadian facilities owing to the improvement in urea demand. Agrium's Fort Saskatchewan nitrogen facility has the capacity to produce 465,000 t/yr of ammonia and 430,000 t/yr of urea (Fertilizer Week, 2009b).

China.—Hangfeng Evergreen Inc. planned to build an additional polymer-coated urea (PCU) production line with its 50-50 joint-venture partner Shandong Mingshui Great Chemical Group. The new PCU line would have a production capacity of 100,000 t/yr and would share the infrastructure, utility supplies, and operational management with the existing PCU and sulfur-coated urea units located in Shandong Province. The new line was scheduled for completion in the third quarter of 2010 at a cost of $5 million (Fertilizer Week, 2009i).

Sichuan Hongda Co. Ltd. planned to invest $141 million in chemical projects through its subsidiary Sichuan Mianzhu Chuanrun Chemical Co. Ltd. Plans were to construct a 200,000-t/yr ammonia plant, 300,000-t/yr urea plant, and a 300,000-t/yr compound fertilizer unit. No timetable for construction was announced (Fertilizer Week, 2009o).

In December, the Chinese Government released its 2010 tariff rates for many products, including urea, to discourage exports during periods of high domestic demand. The surcharge for urea would be 110% during the high seasons, which were from February 1 through June 30 and September 16 through October 15 (Fertilizer Week America, 2009).

Egypt.—Egypt's Industrial Development Authority approved the construction of a nitrogen fertilizer production line, which would be located at Egyptian Chemical Industries' (KIMA) Aswan facility. The new line would produce 600,000 t/yr of urea and 600,000 t/yr of ammonium nitrate. No timetable for construction was identified (Daily News Egypt, 2009).

Egyptian Nitrogen Products Co. SAE secured financing of $1.05 billion to support the construction of second and third urea trains at the existing Misr Oil Processing Co. (MOPCO) nitrogen facility in Damietta. Total production at the MOPCO site would increase to 1.95 Mt/yr of urea and 150,000 t/yr of merchant ammonia. Construction of both trains was expected to be completed in the first half of 2012 (Fertilizer Week, 2009a).

Estonia.—Nitrofert JSC suspended ammonia and urea production at its Ida-Viruuma plant in February owing to market conditions and high raw material costs. The plant had one ammonia train with a capacity to produce 200,000 t/yr and two urea trains, each with a production capacity of 108,000 t/yr (Fertilizer Week, 2009k).

France.—In mid-March, Yara International ASA restarted ammonia and urea production at its Le Havre plant following an improvement in international urea prices and lower energy costs. Production capacity at the plant was 400,000 t/yr ammonia and 350,000 t/yr urea when fully operational (Nitrogen + Syngas, 2009i).

India.—Krishak Bharati Cooperative Ltd. awarded KBR Inc. a contract to provide licensing and basic engineering services to upgrade two ammonia plants located in Hazari, Surat. KBR was to increase the capacity of each ammonia plant to 1,890 t/d and to reduce the overall energy consumption at these plants. The upgrade of the ammonia plants began in 2009 (KBR Inc., 2009).

Fertilisers and Chemicals Travancore Ltd. secured permission from India's Department of Fertilisers to establish a new 500,000-t/yr urea plant. The plant would be based on natural gas feedstock at a cost of about $130 million. No timetable for construction was announced (Nitrogen + Syngas, 2009b).

Italy.—Yara restarted ammonia and urea production at its Ferrara plant in northern Italy in late February. The plant was restarted based on improvement in international urea markets and increased seasonal demand for urea in Italy. The plant had a production capacity of 600,000 t/yr of ammonia and 500,000 t/yr of urea (Nitrogen + Syngas, 2009i).

Libya.—Yara, National Oil Corp. of Libya (NOC), and the Libyan Investment Authority (LIA) signed the final agreements to create the fertilizer joint-venture Libyan Norwegian Fertilizer Co. (Lifeco). Yara, NOC, and LIA would have ownership shares in the new company of 50%, 25%, and 25%, respectively. NOC would transfer to Lifeco the existing Marsa El Brega fertilizer assets, valued at $225 million, while Yara would contribute to Lifeco the corresponding value in cash. NOC would supply natural gas to Lifeco under a long-term agreement. Yara would handle all urea and ammonia exports from Lifeco. The transferred plant would produce 900,000 t/yr of urea and 150,000 t/yr of merchant ammonia (Green Markets, 2009j).

Lithuania.—In June, Achema Group successfully started a 1,050-t/d urea production plant at its site in Jonava. The plant was previously located elsewhere in Europe and had been shut down since the mid-1980s. Technical and equipment modifications were made in order to increase the efficiency of the plant (Nitrogen + Syngas, 2009c).

Nigeria.—Notore Chemical Industries Ltd. began ammonia production in January and urea production in July at its plant in Onne, Rivers State. The plant had the capacity to produce 1,100 t/d of ammonia and 1,500 t/d of granular urea. About $400 million was estimated to have been invested in the extensive rehabilitation of the plant, which had been idled for more than a decade (Fertilizer Week, 2009l).

Oman.—Sohar International Urea and Chemical Industries Co. (SIUCI) (a subsidiary of Suhail Bahwan Group) started production at its $638 million urea and ammonia plant at the Sohar Industrial Port, 250-km northwest of Muscat. The natural gas-feedstock complex would have a 660,000-t/yr ammonia plant and two granular urea plants with a combined capacity of 1.1 Mt/yr (Nitrogen + Syngas, 2009e).

Pakistan.—Engro Chemical Pakistan Ltd. was building a new 745,000-t/yr ammonia and 1.2-Mt/yr prilled urea plant in Dharki, Sindh Province. The plant was expected to begin production in July 2010 (Fertilizer Week, 2009e).

Fatima Fertilizer Co. Ltd. (a joint venture between Fatima Group and Pakistan's Arif Habib Group) planned to start production in December of urea and calcium ammonium nitrate at its new plant at Sadiquabad in the Rahim Yar Khan District of Punjab. The new plant has the capacity to produce 297,000 t/yr of urea and 276,000 t/yr of calcium ammonium nitrate and would use natural gas as the feedstock (Fertilizer Week, 2009h).

Peru.—CF Industries Holdings Inc. signed an agreement for the supply of natural gas to its proposed nitrogen fertilizer complex in San Juan de Marcona. CF Industries would purchase up to 2.8 million cubic meters of natural gas on a take-or-pay basis from a consortium of companies in Peru. The cost for the natural gas used to produce petrochemicals at the facility would be based on the index price for urea. The estimated cost for the project ranged from $1.5 to $2 billion. The expected production capacities were 910,000 t/yr of anhydrous ammonia and 1.3 Mt/yr of urea (Green Markets, 2009a).

Qatar.—The Qatar Fertilizer Co. (Qafco) signed a letter of intent to build a sixth urea plant at its Mesaieed site in eastern Qatar. The Qafco VI urea plant would have a production capacity of 1.27 Mt/yr of urea and would use ammonia feed and share utilities and export arrangements with the Qafco V project. The plant was expected to begin production in late 2012 (Nitrogen + Syngas, 2010b).

Indian Farmers Fertilizer Cooperative Ltd. (IFFCO) and Qafco signed a memorandum of understanding to establish a joint-venture ammonia and urea complex in Qatar. Qafco would have 51% stake in the proposed joint venture, and IFFCO would hold a 49% stake. No timetable for construction was identified (Fertilizer Week, 2009g).

Russia.—Azot Cherepovets, part of the PhosAgro Group, began building infrastructure facilities for a 1,500-t/d urea plant at Cherepovets. The urea plant, which would use surplus urea from Azot Cherpovet's existing facilities, was expected to start production by the beginning of 2012 (Fertilizer Week, 2009c).

Saudi Arabia.—KBR was awarded a contract by Al-Jubail Fertilizer Co. to upgrade the Al-Bayroni ammonia plant. KBR would provide engineering design, procurement, and installation support services for a new auxiliary boiler and a reformer convection section for the ammonia plant. The plant was originally built in the 1980s utilizing KBR's ammonia technology (Green Markets, 2009e).

Ukraine.—In January, the natural gas cost dispute between Russia and Ukraine led to a number of fertilizer plants shutting down as well as a decrease in fertilizer production in Ukraine and across Europe. In June, Ukraine paid $475 million to OAO Gazprom (Russia's national energy company) to stop another potential crisis over debts and another shutdown of natural gas supplies. They also agreed upon a 2009 natural gas price that would be paid by Ukraine. Ukrainian fertilizer producers still faced high gas prices in spite of negotiations between the Ukranian national energy company Naftogaz Ukrainy and Gazprom. Ukrainian producers appealed to their Government to buy directly from Gazprom, but the proposal was not approved by the Government (Nitrogen + Syngas, 2009g).

United Arab Emirates.—Ruwais Fertilizer Industries (Fertil) awarded Samsung Engineering Co., Ltd. a contract to build its Fertil II ammonia-urea plant at Ruwais. Fertil II was projected to have a capacity of 660,000 t/yr of ammonia and 1.15 Mt/yr of urea. The plant was scheduled to come online in January 2013 at a cost of $1.2 billion (Nitrogen + Syngas, 2010a).

Uzbekistan.—Uzbek Chemical Industry and International Petroleum Investment Co. planned to build an industrial complex to produce ammonia and carbamide. The complex would have a capacity to produce 900,000 t/yr of ammonia and 1 Mt/yr of carbamide at a cost of $1.34 billion. Construction was planned to begin in 2010 and be completed by 2013 (Trend News Agency, 2009).

Venezuela.—Pequiven (Petroquimica de Venezuela) S.A. (a subsidiary of Venezuela's oil company Petróleos de Venezuela S.A.) awarded two contracts to Stamicarbon to provide the license and process design package for two new urea plants, one in Jose and the other in Puerto Nutrias. Production was expected to start at the Jose plant in 2011. The Jose plant would have two lines, each with a production capacity of 2,200 t/d of urea. The Puerto Nutrias was expected to begin production in 2012 with one line having a production capacity of 2,200 t/d of urea (Nitrogen + Syngas, 2009h).

Zimbabwe.—Sable Chemicals Industries Ltd. closed the ammonia line at its nitrogen fertilizer plant in Kwekwe. Sable had used the ammonia to produce ammonium nitrate onsite, but would import ammonia instead. The 76,000-t/yr ammonia plant was built in the 1960s (Nitrogen + Syngas, 2009d).

Outlook

According to the USDA, U.S. corn growers intended to plant 34.4 million hectares (Mha) of corn for all purposes in the 2010 crop year, an increase of 3% from that in 2009 and 2008 (U.S. Department of Agriculture, National Agricultural Statistical Service, 2010, p. 1). Expected corn acreage utilization was up in many States because of reduced winter wheat acreage utilization and expectations of higher selling prices.

According to long-term projections from the USDA, projected plantings for the eight major field crops (barley, corn, oats, rice, sorghum, soybeans, upland cotton, and wheat) in the United States were expected to decrease slightly to about 100 Mha during the projection period (2010–19) from about 101 Mha in 2009. Increased cropland availability (resulting from the reduction in the allowable acreage enrolled in the Conservation Reserve Program) and sustained high commodity prices were expected to keep projected U.S. cropland use high, although overall plantings would be somewhat reduced from the 2009 and 2008 levels. Corn, soybeans, and wheat were expected to account for about 89% of acreage utilization for the eight major field crops during the projection period. During the 10-year period, the crop mix was expected to keep corn acreage high. Soybean planting would initially fall but as stocks are reduced, prices would improve, and plantings increase. Wheat plantings would decline as a result of weak demand and significant quantities of stocks. Continued increases were projected for corn used to produce ethanol during the next 10 years; however, the pace was expected to slow from the rapid gains of 2007 and 2008. Most ethanol production used corn as a feedstock, with nearly one-third of total corn use expected to go to ethanol production in 2009 and 2010. Projected gains were largely in line with moderate expected increases in overall gasoline usage in the United States. Relatively high prices for crude oil would be favorable for ethanol production, which, when combined with Government programs, would provide economic incentives for ethanol producers.

Feed and residual use of corn was projected to bottom out in the initial years owing to reduced meat production and increased feeding of distillers grains (a coproduct of dry mill ethanol production). Feed use was expected to rise through the rest of the period as meat production increases and growth in availability of distillers grains slows with the decrease in corn-based ethanol expansion. Gains in food and industrial uses of corn (other than for ethanol production) were projected to rise during the next decade. Consumer dietary concerns and other changes in tastes and preferences limit increases in the combined use of corn for dextrose, glucose, and high-fructose corn syrup to about one-half the rate of population gain. Other food uses of corn are also projected to rise more slowly than the increase in population. U.S. corn exports rise in response to stronger global demand for feed grains to support growth in meat production, with the U.S. share of global corn trade decreasing below 60%. Larger corn plantings increase the demand for nitrogen fertilizers (U.S. Department of Agriculture, Economic Research Service, 2010b, p. 58).

In 2009, natural gas prices fell to their lowest level in 7 years as a result of a weakened economy, a reduced heating demand, as well as higher than usual production and storage levels. Natural gas prices in the United States typically are higher than those in the rest of the world, but lower natural gas prices make U.S. ammonia production more competitive with offshore imports. Depending on its price, natural gas can account for approximately 75% to 90% of the U.S. cash cost of producing ammonia, and this means that the ammonia capacity at older, higher cost U.S. plants is still at risk for closure. For example, in 2009, natural gas costs in Algeria and the Middle East were estimated to be about $0.60 per million British thermal units (Btus) and $0.80 per million Btus, respectively, and in Trinidad and Tobago, the cost was estimated to be $2.60 per million Btus (Potash Corp. of Saskatchewan, 2009, p. 55). The U.S. Department of Energy projected that the Henry Hub natural gas spot price in the United States would average $4.54 million Btus in 2010, a $0.06 increase from the 2009 average, and $4.76 per million Btus in 2011 (U.S. Department of Energy, Energy Information Administration, 2010, p. 1).

In the winter of 2001, natural gas prices began to spike and continued to increase through the third quarter of 2008, and as a result, U.S. ammonia production capacity has declined by 4.1 Mt/yr, or 24% of the 2001 capacity. In the third quarter of 2008, natural gas prices declined sharply as a result of the downturn in the global economy. During 2009, natural gas prices were relatively low owing to weak industrial demand and competition from shale gas. In 2009, lower natural gas prices made domestic nitrogen production more competitive with imports from major nitrogen-exporting regions. The future of U.S. ammonia production depends on the variability in natural gas prices. The interest that U.S. firms have in constructing new plants outside the United States, particularly in Trinidad and Tobago where natural gas prices are lower, indicates that in the future, much of the U.S. supply of ammonia was expected to be met by foreign production.

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TABLE 1
SALIENT AMMONIA STATISTICS[1, 2]

(Thousand metric tons of contained nitrogen unless otherwise specified)

		2005	2006	2007	2008	2009
United States:						
Production		8,340	8,190	8,540	7,870 [r]	7,700 [p]
Exports		525	193 [r]	145	192	16
Imports for consumption		6,520	5,920	6,530	6,020	4,530
Consumption, apparent[3]		14,400	14,000	15,000	13,600 [r]	12,300 [p]
Stocks, December 31, producers		254	201	157	302 [r]	167
Average annual price, free on board gulf coast[4]	dollars per short ton	304	302	307 [r]	590	251
Net import reliance as a percentage of apparent consumption[5]		41 [r]	41	43	41 [r]	38 [p]
Natural gas price, wellhead, average price[6]	dollars per thousand cubic feet	7.33	6.39	6.25 [r]	7.96 [r]	3.71 [e]
World:						
Production[e]		122,000	126,000	131,000 [r]	130,000 [r]	130,000
Trade[7]		15,600	15,900	15,800	15,400	14,600 [e]

[e] Estimated. [p] Preliminary. [r] Revised.

[1] Data are rounded to no more than three significant digits.

[2] Synthetic anhydrous ammonia, excluding coke oven byproduct; data are for calendar year and are from the U.S. Census Bureau unless otherwise noted.

[3] Calculated from production plus imports minus exports and industry stock changes.

[4] Source: Green Markets.

[5] Defined as imports minus exports; adjusted for industry stock changes.

[6] Source: Monthly Energy Review, U.S. Department of Energy.

[7] Source: International Fertilizer Industry Association Statistics, World Anhydrous Ammonia Trade.

TABLE 2
ANHYDROUS AMMONIA SUPPLY AND DEMAND IN THE UNITED STATES[1]

(Thousand metric tons of contained nitrogen)

	2007	2008	2009^{p}
Production:			
Fertilizer:			
January–June	3,890	3,520 ^{r}	3,040
July–December	3,720	3,210 ^{r}	3,430
Total	7,610	6,730 ^{r}	6,470
Nonfertilizer:			
January–June	478	542 ^{r}	603
July–December	452	594 ^{r}	632
Total	930	1,140 ^{r}	1,240
Grand total	8,540	7,870 ^{r}	7,700
Exports:			
January–June	56	53	9
July–December	89	139	7
Total	145	192	16
Imports for consumption:			
January–June	3,310 ^{r}	3,290 ^{r}	2,180
July–December	3,210	2,720	2,340
Total	6,530	6,020	4,530
Stocks, end of period:			
January–June	222	193 ^{r}	201
July–December	157	302 ^{r}	167
Apparent consumption:[2]			
January–June	7,630	7,330 ^{r}	5,810
July–December	7,340	6,250 ^{r}	6,530
Total	15,000	13,600 ^{r}	12,300

^{p}Preliminary. ^{r}Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Calculated from production plus imports minus exports and industry stock changes.

Source: U.S. Census Bureau.

TABLE 3
MAJOR DOWNSTREAM NITROGEN COMPOUNDS PRODUCED IN THE UNITED STATES[1, 2]

(Thousand metric tons)

	2008						2009^{p}					
	January–June		July–December		Total		January–June		July–December		Total	
	Gross weight	Nitrogen content	Gross weight	Nitrogen content	Gross weight	Nitrogen content	Gross weight	Nitrogen content	Gross weight	Nitrogen content	Gross weight	Nitrogen content
Urea	2,690	1,240	2,550	1,170	5,240	2,410	2,490	1,140	2,600	1,190	5,080	2,330
Ammonium nitrate	3,640	1,230	3,470	1,180	7,110	2,410	2,920	991	3,380	1,140	6,300	2,140
Ammonium phosphates[3]	6,200	963	5,160	815	11,400 ^{r}	1,780	5,090	815	6,310	1,010	11,400	1,820
Nitric acid	3,460 ^{r}	762 ^{r}	3,220 ^{r}	709 ^{r}	6,690 ^{r}	1,470 ^{r}	2,560	562	3,370	741	5,930	1,300
Ammonium sulfate[4]	1,410	298	1,120 ^{r}	237 ^{r}	2,530 ^{r}	535 ^{r}	1,160	246	1,110	235	2,270	481

^{p}Preliminary. ^{r}Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Ranked in relative order of importance by nitrogen content.

[3] Diammonium phosphate and monoammonium phosphate.

[4] Excludes coke plant ammonium sulfate.

Source: U.S. Census Bureau, Current Industrial Reports MQ325B.

TABLE 4

DOMESTIC PRODUCERS OF ANHYDROUS AMMONIA IN 2009[1]

(Thousand metric tons per year of ammonia)

Company	Location	Capacity[2]
Agrium Inc.	Borger, TX	490
Do.	Kennewick, WA[3]	180
CF Industries Holdings, Inc.	Donaldsonville, LA	2,040
Coffeyville Resources Nitrogen Fertilizers, LLC	Coffeyville, KS	375
Dakota Gasification Co.	Beulah, ND	363
Dyno Nobel Inc.	Cheyenne, WY	174
Do.	St. Helens, OR	101
Eastman Chemical Co.	Beaumont, TX[3]	231
Green Valley Chemical Corp.	Creston, IA	32
Honeywell International Inc.	Hopewell, VA	530
Koch Nitrogen Co.	Beatrice, NE	265
Do.	Dodge City, KS	280
Do.	Enid, OK	930
Do.	Fort Dodge, IA	350
Do.	Sterlington, LA[3]	1,110
LSB Industries, Inc.	Cherokee, AL	159
Do.	Pryor, OK[3]	210
Mosaic Co., The	Faustina (Donaldsonville), LA	508
PCS Nitrogen, Inc.	Augusta, GA	688
Do.	Geismar, LA[3]	483
Do.	Lima, OH	542
Do.	Memphis, TN[3]	372
Rentech Energy Midwest Corp.	East Dubuque, IL	278
Terra Industries Inc.	Donaldsonville, LA	454
Do.	Port Neal, IA	336
Do.	Verdigris, OK	953
Do.	Woodward, OK	399
Do.	Yazoo City, MS	454
Total		13,300

Do. Ditto.

[1] Data are rounded to no more than three significant digits; may not add to total shown.

[2] Engineering design capacity adjusted for 340 days per year of effective production capability.

[3] Idle.

TABLE 5

U.S. NITROGEN FERTILIZER CONSUMPTION, BY PRODUCT TYPE[1, 2]

(Thousand metric tons of nitrogen)

Fertilizer material[3]	2008[r]	2009[e]
Single-nutrient:		
Anhydrous ammonia	3,440	3,480
Nitrogen solutions[4]	2,890	2,930
Urea	2,260	2,290
Ammonium nitrate	267	271
Ammonium sulfate	250	254
Aqua ammonia	85	86
Other[5]	355	360
Total	9,540	9,670
Multiple-nutrient[6]	1,950	1,970
Grand total	11,500	11,600

[e]Estimated. [r]Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Fertilizer years ending June 30.

[3] Ranked in relative order of importance by product type.

[4] Principally urea-ammonium nitrate solutions, 29.9% nitrogen.

[5] Includes other single-nutrient nitrogen materials, all natural organics, and statistical discrepencies.

[6] Various combinations of nitrogen (N), phosphate (P), and potassium (K): N-P-K, N-P, and N-K.

Source: Slater, J.V. and Kirby, B.J., 2010, Commercial Fertilizers 2008: Columbia, MO, Association of American Plant Food Control Officials Inc. Fertilizer/Ag Lime Control Service, University of Missouri, 41 p.

TABLE 6
U.S. PRODUCER STOCKS OF FIXED NITROGEN COMPOUNDS AT END OF PERIOD

(Thousand metric tons of contained nitrogen)

Material[1]	2008	2009 [p]
Ammonia:		
January–June	193 [r]	201
July–December	302 [r]	167
Nitrogen solutions:[2]		
January–June	212 [r]	153
July–December	286 [r]	95
Urea:		
January–June	32	(3)
July–December	53	(3)
Ammonium phosphates:[4]		
January–June	51 [r]	17 [5]
July–December	30 [5]	44
Ammonium nitrate:		
January–June	48	48
July–December	58 [r]	32
Ammonium sulfate:		
January–June	27	20
July–December	65 [r]	26
Yearend total[6]	794 [r]	364

[p] Preliminary. [r] Revised.

[1] Ranked in relative order of importance.

[2] Urea-ammonium nitrate and ammoniacal solutions.

[3] Urea data withheld.

[4] Diammonium and monoammonium phosphates.

[5] Diammonium phosphates data withheld.

[6] Calendar year ending December 31.

Source: U.S. Census Bureau, Current Industrial Reports MQ325B.

TABLE 7
PRICE QUOTATIONS FOR MAJOR NITROGEN COMPOUNDS AT END OF PERIOD

(Dollars per short ton)

Compound	2008		2009	
	June	December	June	December
Ammonium nitrate, free on board (f.o.b.) corn belt[1]	400–410	300–330	265–270	265–270
Ammonium sulfate, f.o.b. corn belt[1]	400–420	200–210	225–245	185–210
Anhydrous ammonia:				
F.o.b. corn belt[1]	725–860	450–650	300–345	340–390
F.o.b. gulf coast[2]	500–520	120	255	275
Diammonium phosphate, f.o.b. central Florida	1,025–1,070	300–305	250–255	320
Urea:				
F.o.b. corn belt,[1] prilled and granular	685–705	270–330	270–285	350–360
F.o.b. gulf coast, granular[2]	680–715	190–210	240–245	307–315

[1] Illinois, Indiana, Iowa, Missouri, Nebraska, and Ohio.

[2] Barge, New Orleans, LA.

Source: Green Markets.

TABLE 8

U.S. EXPORTS OF ANHYDROUS AMMONIA, BY COUNTRY[1]

(Thousand metric tons of ammonia and thousand dollars)

	2008		2009	
Country	Gross weight	Value[2]	Gross weight	Value[2]
Belgium	2	385	1	526
Canada	215	31,700 r	15	7,190
Haiti	(3)	118	1	207
Israel	(3)	81	1	288
Other	16 r	3,220 r	2	861
Total	233 r	35,500	20	9,070

rRevised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight value.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9

U.S. IMPORTS OF ANHYDROUS AMMONIA, BY COUNTRY[1]

(Thousand metric tons of ammonia and thousand dollars)

	2008		2009	
Country	Gross weight	Value[2]	Gross weight	Value[2]
Australia	--	--	80	22,200
Canada	933	736,000	822	357,000
Egypt	--	--	96	29,400
Russia	1,440	827,000	438	133,000
Trinidad and Tobago	3,810	2,140,000	3,720	936,000
Ukraine	553	339,000	67	20,400
Venezuela	213	117,000	158	36,900
Other	371	214,000 r	126	36,000
Total	7,320	4,370,000	5,510	1,570,000

rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight value.

Source: U.S. Census Bureau.

TABLE 10
U.S. EXPORTS OF MAJOR NITROGEN COMPOUNDS[1]

(Thousand metric tons)

Compound	2008 Gross weight	2008 Nitrogen content	2009 Gross weight	2009 Nitrogen content	Principal destinations in 2009
Ammonium nitrate[2]	189	64	364	123	France, 46%; Canada, 21%; Mexico, 20%.
Ammonium sulfate[2]	1,620	343 r	963	204	Brazil, 39%; Peru, 13%; Mexico, 12%.
Anhydrous ammonia	234 r	192	20	16	Canada, 78%; Belgium, 6%.
Diammonium phosphate	4,530	816 r	5,530	996	India, 58%; China, 6%.
Monoammonium phosphate	2,490	274	2,110	232	Canada, 29%; Brazil, 24%; Australia, 12%; Argentina, 11%.
Urea	302	139	289	133	Canada, 35%; Colombia, 12%; Mexico, 12%.
Total	9,370 r	1,830 r	9,280	1,700	

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes industrial chemical products.

Source: U.S. Census Bureau.

TABLE 11
U.S. IMPORTS OF MAJOR NITROGEN COMPOUNDS[1]

(Thousand metric tons and thousand dollars)

Compound	2008 Gross weight	2008 Nitrogen content	2008 Value[2]	2009 Gross weight	2009 Nitrogen content	2009 Value[2]	Principal sources in 2009
Ammonium nitrate[3]	707	240	230,000	451	153	98,900	Canada, 79%; Netherlands, 15%.
Ammonium nitrate and limestone mixtures	6	2	2,540	51	14	11,100	Greece, 39%; Russia, 38%; Lithuania, 14%.
Ammonium sulfate[3]	395	84	99,100	324	69	67,300	Canada, 99%.
Anhydrous ammonia[4]	7,320	6,020	4,370,000	5,510	4,530	1,570,000	Trinidad and Tobago, 68%; Canada, 15%.
Calcium nitrate	205	35	29,200	123	21	14,600	Norway, 97%.
Diammonium phosphate	31	6	13,400	22	4	9,710	Mexico, 75%; Germany 15%.
Monoammonium phosphate	176	19	158,000	57	6	34,500	Canada, 63%; Russia, 15%.
Nitrogen solutions	6,950	2,080	930,000	1,170	349	257,000	Russia, 51%; Canada, 33%.
Potassium nitrate	133	19	80,200	74	10	48,500	Chile, 87%.
Potassium nitrate and sodium nitrate mixtures	(5)	(5)	191	1	(5)	274	Germany, 66%; Canada, 30%.
Sodium nitrate	157	26	31,700	84	14	20,600	Chile, 95%.
Urea	5,460	2,510	2,870,000	4,730	2,170	1,440,000	Canada, 35%; Saudi Arabia, 11%; Qatar, 10%.
Total	21,500	11,000	8,810,000	12,600	7,330	3,570,000	

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight value.

[3] Includes industrial chemical products.

[4] Includes industrial ammonia.

[5] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 12

AMMONIA: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons, contained nitrogen)

Country	2005	2006	2007	2008	2009
Afghanistan	20	20	20	20	20
Albania	10	10	10	10	10
Algeria	550 [3]	470	524	500	614
Argentina	655 [3]	727 [3]	726	726	726
Australia	790	1,200	1,200	1,200	1,200
Austria	440	440	440	440	400
Bahrain	330 [3]	370 [3]	344 [3]	350	350
Bangladesh[4]	1,380 [3]	1,250	1,300	1,300	1,300
Belarus	774 [3]	815	830	805 [3]	750
Belgium	860 [3]	850	850	850	850
Bosnia and Herzegovina	1	1	1	1	1
Brazil	950	950	950	950	950
Bulgaria	320 [3]	309	310	310	310
Burma	30	30	30	30	30
Canada	4,100	4,100	4,498 [3]	4,781 [3]	4,000
China[3]	37,850	40,660	42,480	41,140 [r]	42,290
Colombia	-- [r]	-- [r]	-- [r]	-- [r]	--
Croatia	320 [3]	319 [3]	320	320	320
Cuba	28	42 [3]	47 [3]	42 [r]	42
Czech Republic	250 [3]	250	225	200	200
Denmark	2	2	2	2	2
Egypt	1,640 [3]	1,800	1,750	1,750	2,000
Estonia	170 [3]	170	170	170	170
Finland	63	62	62	62	62
France	1,206 [3]	616 [3]	800	800	800
Georgia	130	140	150	150	150
Germany[3]	2,789	2,718	2,746	2,819	2,363
Greece	130 [3]	130	130	130	125
Hungary	275 [3]	275	300	300	300
India[5]	10,800	10,900	11,000	11,100	11,200
Indonesia	4,400 [3]	4,300	4,400	4,500	4,600
Iran	1,020 [3]	1,020	2,000	2,000	2,000
Iraq	30	10	10	10	10
Italy	525 [3]	480 [3]	460	460	460
Japan	1,083 [3]	1,091 [3]	1,114 [3]	1,110	1,120
Korea, North	100	100	100	100	100
Korea, Republic of	165	90	-- [r]	-- [r]	--
Kuwait	467 [3]	495 [r]	485 [r]	485 [r]	475
Libya	507	518 [r, 3]	523 [r, 3]	417 [r, 3]	500
Lithuania	430 [3]	453 [3]	936 [3]	950	950
Malaysia	920	950	960	950	950
Mexico	423 [3]	487 [3]	487 [3]	625 [3]	624
Netherlands	1,700 [3]	1,800	1,800	1,800	1,800
New Zealand	120 [3]	120	125	125	125
Norway	300 [3]	350	350	350	350
Oman	620 [3]	1,000	1,000	1,000	1,000
Pakistan	2,114 [3]	2,200	2,250	2,300	2,300
Peru	5	5	5	5	5
Poland	2,080 [3]	2,007 [3]	1,995 [3]	1,995 [r, 3]	1,990
Portugal	244 [3]	244	244	244	244
Qatar	1,754 [3]	1,784 [3]	1,800	1,800	1,800
Romania	1,300	1,300	1,300	1,300	1,300

See footnotes at end of table.

TABLE 12—Continued

AMMONIA: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons, contained nitrogen)

Country	2005	2006	2007	2008	2009
Russia	10,000 [3]	10,500 [3]	10,500	10,425 [3]	10,441 [3]
Saudi Arabia	1,780 [3]	2,000	2,600	2,600	2,600
Serbia	111 [3, 6]	80	85	85	85
Slovakia	236 [3]	241 [3]	260 [r]	260 [r]	260
South Africa	460 [3]	480	480	480	430
Spain	460 [3]	400	400	400	400
Switzerland	32 [3]	32	32	32	32
Syria	120	120	120	120	210
Taiwan	11	12	12	12	12
Tajikistan	45	35	25	25	20
Trinidad and Tobago	5,187 [3]	5,111 [3]	5,129 [3]	5,130	5,100
Turkey	305 [3]	92 [3]	-- [3]	50	100
Turkmenistan	220	250	270	270	270
Ukraine	4,300 [3]	4,200	4,200	4,200 [r]	4,200
United Arab Emirates	360 [3]	380	380	380	380
United Kingdom	1,080 [3]	750	1,050	1,100	1,100
United States[3, 7]	8,338	8,190	8,538	7,867 [r]	7,704
Uzbekistan	880 [3]	940	1,000	1,000	1,000
Venezuela	900 [3]	1,160	1,160	1,160	1,160
Vietnam	220	230	300	300	300
Zimbabwe	30	10	35	25 [r]	20
Total	122,000	126,000	131,000 [r]	130,000 [r]	130,000

[r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data have been rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 10, 2010.

[3] Reported figure.

[4] May include nitrogen content of urea.

[5] Data are for years beginning April 1 of that stated.

[6] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[7] Synthetic anhydrous ammonia; excludes coke oven byproduct ammonia.

PEAT

By Lori E. Apodaca

Domestic survey data and tables were prepared by Danielle L. Militello, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2009, peat produced in the conterminous United States was 609,000 metric tons (t); output from Alaska was estimated to be 182,000 cubic meters (Hughes and other, 2010, p.11).

The United States was a significant producer and consumer of peat for horticultural and industrial purposes. The types of peat are classified according to the degree of decomposed component plant material, with sphagnum moss being the least decomposed followed by hypnum moss, reed-sedge, and humus.

Reed-sedge accounted for 83% of domestic peat production, followed by sphagnum moss with 8%; hypnum moss with 6%; and humus with 3% (table 4). Florida accounted for 78% of U.S. peat production with 476,000 t (table 3).

Peat is a renewable natural organic material of botanical origin and commercial significance. Peatlands are situated in wetland areas, primarily in the temperate and cold belt of the Northern Hemisphere, where large peat deposits developed from the gradual decomposition of plant matter under anaerobic conditions. The United States contains approximately 15% of the world's peatlands by area (Lappalainen, 1996, p. 55). There are more than 400 million hectares (Mha) of peatlands on Earth, of which 80% remains undisturbed. Of the 80 Mha that has been used by humans, 50% has been used for agriculture; 30%, for forestry; 10%, for miscellaneous uses; and 10%, for peat extraction. Peat continues to accumulate on 60% of global peatlands; however, the volume of global peat resources has been decreasing at a rate of 0.05% per year owing to human activity (Joosten and Clarke, 2002, p. 32–33).

Production

Domestic production data for peat were developed by the U.S. Geological Survey from a voluntary canvass of operations in the conterminous United States. Of the 50 operations to which a survey request was sent, 35 responded, representing 70% of total production tonnage. From the respondents, there were 32 active operations, 2 idle operations, and 1 closed operation in 2009. Data for nonrespondents were estimated based on responses to the 2008 survey or other sources. Most peat operations are relatively small and sell their products regionally. Peat production in the conterminous United States in 2009 was 609,000 t, a slight decrease from that of 2008 (table 1). A decrease in peat production of 5% was reported in the Eastern region, and an increase of 21% was reported for the Great Lakes region. In 2009, 74% of domestic production came from just five operations (table 2). Output from Alaska was estimated to be 182,000 cubic meters in 2009, according to the Alaska Department of Natural Resources, which conducted its own survey of mineral production in the State (Hughes and others, 2010, p. 11). Peat production in Alaska was reported by volume only.

Consumption

Peat is widely used as a plant-growth medium in a variety of agricultural and horticultural applications where its fibrous structure and porosity enable a unique combination of water-retention and drainage characteristics. Commercial applications include lawn and garden soil amendments, potting soils, and turf maintenance on golf courses. In industry, peat is used primarily as a filtration medium to remove toxic materials from process waste streams, pathogens from sewage effluents, and deleterious materials suspended in municipal storm-drain water. In its dehydrated form, peat is a highly effective absorbent for fuel and oil spills on land and water.

Sales of domestic peat decreased slightly to 644,000 t in 2009 from 648,000 t in 2008. Packaged products composed 13% of total domestic sales tonnage and commanded premium prices for all grades of peat. Apparent consumption was estimated to be the same as that of 2008. Potting soil and general soil improvement mixes were the two leading usage categories, accounting for 89% of domestic sales tonnage and 83% of the volume (table 5). Other significant uses, by quantity of sales, included nursery applications, golf course applications, and seed inoculants. The United States imported 61% of total consumption requirements, primarily from Canada, where deposits of high-quality sphagnum moss are extensive. Canadian peat was sold in bulk for blending in custom soil mixes and was packaged for horticultural use; however, a detailed distribution of Canadian imports was not available. Many of the soil blending facilities in the Southern and Western United States are owned by subsidiaries of Canadian peat producers and import much of their peat requirements.

Stocks

U.S. yearend stocks of peat decreased slightly to 149,000 t in 2009 from 152,000 t in 2008 (table 1). Reed-sedge peat accounted for 77% of total stocks, followed by hypnum moss, sphagnum moss, and humus (table 4).

Prices

The total reported free on board (f.o.b.) value for domestic peat sold in the United States was $15 million, according to the annual survey of domestic peat producers. The average unit value decreased to $23.24 per metric ton compared with $26.42 per ton in 2008 (table 1). On an average unit-value basis, sphagnum moss was valued at $68.61 per ton, f.o.b. plant; humus, $30.04 per ton; hypnum moss, $29.61 per ton; and reed-sedge, $19.74 per ton (table 7).

Foreign Trade

U.S. companies exported 77,000 t of peat (tables 1, 8). Imports of peat decreased by about 3% to 906,000 t from 936,000 t in 2008 (table 8). The total customs import value was $230 million or $254.15 per ton. Imports of peat (sphagnum moss) from Canada decreased to 871,000 t, which represented 96% of total U.S. imports and 77% of total Canadian production.

World Review

Finland, Ireland, Belarus, Russia, Sweden, Canada, and Latvia were the leading peat producing countries in decreasing order of tonnage (table 9). World peat production for 2009 was estimated to be 25 million metric tons (Mt), a slight increase from that of 2008. Other significant producing countries included Estonia, Poland, the United States, and Lithuania. Peat is an important source of energy in Finland, Ireland, and Sweden and to a lesser extent in Eastern Europe.

Canada.—Production of peat (sphagnum moss) was estimated to have decreased to 1.13 Mt in 2009 from 1.15 Mt in 2008. New Brunswick, Quebec, and Manitoba were the major producing provinces, in decreasing order of tonnage, accounting for 84% of production. Alberta, British Columbia, Newfoundland, Nova Scotia, Prince Edward Island, and Saskatchewan also reported peat production (Natural Resources Canada, 2010).

In 2009, Peat Resources Ltd.'s small-scale production facility in Stephenville, Newfoundland, produced more than 200 t of high-quality peat fuel pellets for testing and marketing purposes (Peat Resources Ltd., 2009).

As part of the Canadian Government's economic action plan, the town of Carrot River, Saskatchewan, received C$5 million to build a 22-kilometer public road to access a new peat moss deposit, providing Premiere Horticulture Ltd. with a 20-year supply of peat moss and the ability to continue mining peat in the province (Western Economic Diversification Canada, 2009).

Ireland.—Bord na Mona Energy Ltd. planned to phase out the use of peat bogs to fuel power stations during the next 20 years. The company did not plan to open any more new bogs, as the existing peat bogs have the capacity to fuel the power generation stations for approximately 20 years. Renewable energy sources were planned for fueling the power stations in the future (Business and Leadership Ltd., 2009).

Rwanda.—Rwanda's sole cement manufacturer, CIMERWA, was set to benefit from peat mining. Peat, expected to replace the high-cost heavy fuel oil, was being mined at Gishoma in Rusizi district from a 144-hectare deposit by a newly created Rwanda Investment Group company called Peat Energy Company. Plans were to convert the energy source for the cement plant to 70% peat and 30% fuel technology (New Times, The, 2009).

Outlook

The domestic short-term peat situation will likely include steadily increasing Canadian imports and fluctuating domestic peat production. The number of domestic producers will likely continue to decline and remain dominated by large companies. Other factors, such as competition from organic soil amendments like coir (coconut fiber) and composted yard waste, Federal and State wetlands regulations, and restriction on permitting new production sites will likely have a negative influence on growth of the domestic peat industry. Also, peatlands have been identified as carbon sinks, storing more carbon dioxide per unit hectare than any other ecosystem. Preservation of peatlands may become a high priority in the efforts to reduce greenhouse gas emissions.

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TABLE 1

SALIENT PEAT STATISTICS[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

	2005	2006	2007	2008	2009
United States:[2]					
Number of active producers	45	39	38	37	38
Production	685	551	635	615	609
Sales by producers:					
Quantity:					
Bulk	537	525	590	546	559
Packaged	214	209	104	102	85
Total	751	734	694	648	644
Value	20,800	20,100	17,700	17,100	15,000
Average value dollars per metric ton	27.76	27.34	25.59	26.42	23.24
Average value, bulk do.	23.08	23.00	24.69	24.73	22.06
Average value, packaged or baled do.	39.54	38.28	30.64	36.24	31.01
Exports	36	41	56	57 r, e	77
Imports for consumption	891	924	977	936	906
Consumption, apparent[3]	1,600	1,500	1,590	1,440	1,440
Stocks, December 31, producers'	195	128	98	152	149
World, production	26,000	25,700 r	25,600 r	24,900 r	25,000 e

e Estimated. r Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits, except average values per metric ton.

[2] Excludes Alaska.

[3] Apparent consumption equals U.S. production plus imports minus exports plus adjustments for industry stock changes.

TABLE 2

RELATIVE SIZE OF PEAT OPERATIONS IN THE UNITED STATES

Size (metric tons per year)	Active operations 2008	Active operations 2009	Production (thousand metric tons) 2008	Production (thousand metric tons) 2009
23,000 and more	4	5	455	453
9,000 to 22,999	6	7	96	97
5,000 to 8,999	4	5	25	33
1,000 to 4,999	11	11	33	22
Less than 1,000	12	10	6	4
Total	37	38	615	609

TABLE 3
U.S. PEAT PRODUCTION AND SALES BY PRODUCERS IN 2009, BY STATE[1]

Region and State	Active operations	Production (thousand metric tons)	Sales: Quantity (thousand metric tons)	Sales: Value[2] (thousands)	Sales: Percentage packaged
East:					
Florida	7	476	527	$10,100	5
Pennsylvania	4	3	3	90	65
Other[3]	7	28	27	1,310	60
Total or average	18	507	557	11,500	43
Great Lakes:					
Minnesota	9	63	44	2,850	54
Other[4]	8	36	38	471	38
Total or average	17	99	82	3,320	46
West[5]	3	4	5	140	26
Grand total or average	38	609	644	15,000	13

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Values for free on board producing plant.

[3] Includes Maine, New Jersey, and New York.

[4] Includes Illinois, Indiana, Michigan, and Ohio.

[5] Includes Iowa, Washington, and Wisconsin.

TABLE 4
U.S. PEAT PRODUCTION AND PRODUCERS' YEAREND STOCKS IN 2009, BY TYPE

Type	Active operations[1]	Production[2] (metric tons)	Percentage of production	Yearend stocks[2] (metric tons)
Sphagnum moss	9	48,100	8	9,370
Hypnum moss	5	35,600	6	18,600
Reed-sedge	16	510,000	83	114,000
Humus	8	15,900	3	6,430
Total	38	609,000	100	149,000

[1] Some plants produce multiple types of peat; may not add to totals shown.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 5

U.S. PEAT SALES BY PRODUCERS IN 2009, BY TYPE AND USE[1]

	Sphagnum moss			Hypnum moss			Reed-sedge		
	Quantity			Quantity			Quantity		
Use	Weight (metric tons)	Volume[2] (cubic meters)	Value (thousands)	Weight (metric tons)	Volume (cubic meters)	Value (thousands)	Weight (metric tons)	Volume (cubic meters)	Value (thousands)
Earthworm culture medium	--	--	--	136	500	$2	153	342	$2
General soil improvement	14,200	96,800	$594	4,670	15,800	102	48,800	107,000	705
Golf courses	9,680	60,500	819	381	1,400	6	8,370	36,500	745
Ingredient for potting soils	11,300	8,620	551	2,100	6,780	45	480,000	1,020,000	9,030
Mixed fertilizers	1,280	--	59	272	500	13	--	--	--
Nurseries	233	--	11	26,400	54,100	742	2,500	12,900	189
Packing flowers, plants, shrubs, etc.	5,810	47,500	617	--	--	--	--	--	--
Seed inoculant	--	--	--	--	--	--	8,470	23,800	178
Vegetable growing	7	22	1	41	100	2	227	500	3
Other	1,200	660	13	2,100	4,620	70	--	--	--
Total	43,600	214,000	2,660	36,000	83,800	982	549,000	1,200,000	10,900

	Humus			Total		
	Quantity			Quantity		
	Weight (metric tons)	Volume (cubic meters)	Value (thousands)	Weight (metric tons)	Volume (cubic meters)	Value (thousands)
Earthworm culture medium	236	451	$4	525	1,290	$8
General soil improvement	4,460	7,560	62	72,100	228,000	1,460
Golf courses	3,510	6,450	132	21,900	105,000	1,700
Ingredient for potting soils	6,100	11,200	235	500,000	1,040,000	9,860
Mixed fertilizers	--	--	--	1,550	500	71
Nurseries	660	1,230	27	29,800	68,200	968
Packing flowers, plants, shrubs, etc.	272	500	3	6,090	48,000	620
Seed inoculant	272	500	3	8,750	24,300	181
Vegetable growing	--	--	--	275	622	6
Other	--	--	--	3,290	5,280	82
Total	15,500	27,900	466	644,000	1,530,000	15,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Volume of nearly all sphagnum moss was measured after compaction and packaging.

TABLE 6

AVERAGE DENSITY OF DOMESTIC PEAT SOLD IN 2009

(Kilograms per cubic meter)[1]

	Sphagnum moss	Hypnum moss	Reed-sedge	Humus
Bulk	233	648	596	744
Packaged	160	644	570	704
Bulk and packaged	178	646	593	727

[1] To convert kilograms per cubic meter to pounds per cubic yard multiply by 1.685.

TABLE 7
PRICES FOR PEAT IN 2009[1]

(Dollars per unit)

	Sphagnum moss	Hypnum moss	Reed-sedge	Humus	Average
Domestic:					
Bulk:					
Per metric ton	65.28	28.98	20.37	22.71	22.06
Per cubic meter	15.21	18.77	12.13	16.90	12.06
Packaged or baled:					
Per metric ton	70.25	30.23	12.47	40.53	31.01
Per cubic meter	11.22	19.45	7.11	28.55	11.34
Average:					
Per metric ton	68.61	29.61	19.74	30.04	23.24
Per cubic meter	12.22	19.11	11.71	21.84	12.36
Imported, total, per metric ton[2]	XX	XX	XX	XX	254.15

XX Not applicable.

[1] Prices are free on board plant.

[2] Average customs value.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF PEAT, BY COUNTRY[1]

	2008		2009	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Belgium	--	--	749	$95
Bulgaria	--	--	148	16
Canada	894,000	$215,000	871,000	218,000
Estonia	1,810	303	1,580	361
Finland	662	223	781	317
France	1,060	367	155	52
Germany	379	113	315	69
Ireland	2,490	789	1,690	514
Latvia	29,800	8,970	21,200	6,300
Lithuania	1,140	252	175	36
Netherlands	183	96	585	174
New Zealand	198	101	201	118
Norway	3,090	497	6,690	3,350
Sweden	329	110	1,190	298
Other	623 r	240	318	238
Total	936,000	228,000	906,000	230,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

Source: U.S. Census Bureau.

TABLE 9
PEAT: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2005	2006	2007	2008[e]	2009[e]
Argentina, horticultural use	11	15	14 [r]	10 [r, 4]	10
Australia[e]	6	7	7	7	7
Belarus:					
Horticultural use[e]	100	100	100	100	100
Fuel use	2,308	2,125	2,507	2,500	2,500
Total	2,408	2,225	2,607	2,600	2,600
Burundi, fuel use	5	10	7	10 [r, 4]	10
Canada, horticultural use	1,304	1,245	1,282	1,151 [4]	1,131 [4]
Denmark, horticultural use[e]	298	300	300	300	300
Estonia:					
Horticultural use	1,034	1,207	964	705 [4]	500
Fuel use	378	507	475	213 [r, 4]	328 [4]
Total	1,412	1,714	1,439	919 [r, 4]	828
Finland:[e]					
Horticultural use	900	900	900	900	900
Fuel use	8,200	8,200	8,200	8,200	8,200
Total	9,100	9,100	9,100	9,100	9,100
France, horticultural use[e]	200	200	200	200	200
Germany, horticultural use	116 [r]	108 [r]	112 [r]	99 [r, 4]	94
Hungary, horticultural use[e]	75	77 [4]	90	90	90
Ireland:[e, 5]					
Horticultural use	475	500	500	500	500
Fuel use	4,100 [4]	3,800	3,800	3,800	3,800
Total	4,575 [4]	4,300	4,300	4,300	4,300
Latvia, horticultural and fuel uses	791	931	1,000 [e]	1,000	1,000
Lithuania:					
Horticultural use	536	471	308	307 [4]	521 [4]
Fuel use	68	50	15	15	15
Total	604	521	323	322 [4]	536
Moldova, fuel use[e]	475	475	475	475	475
New Zealand, horticultural use[e]	26	27	27	27	26
Norway, horticultural use[e]	30	30	30	30	30
Poland, horticultural use[e]	639	577	641	632 [r]	630
Russia, horticultural and fuel uses	1,600	1,400	1,300	1,300 [4]	1,300
Spain[e]	60	60	60	60	60
Sweden:[e]					
Horticultural use	360	400	380	380	380
Fuel use	570	970	900	900	900
Total	930	1,370	1,280	1,280	1,280
Ukraine, horticultural and fuel uses	639	462	395	358 [r, 4]	360
United Kingdom[e]	(6) [4]	(6)	(6)	(6)	(6)
United States, horticultural use	685	551	635	615 [4]	609 [4]
Grand total	26,000	25,700 [r]	25,600 [r]	24,900 [r]	25,000
Of which:					
Horticultural use	6,790 [r]	6,710 [r]	6,480 [r]	6,050 [r]	6,020
Fuel use	16,100	16,100	16,400	16,100	16,200
Unspecified	3,100	2,860	2,760	2,730 [r]	2,730

[e] Estimated. [r] Revised.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 24, 2010.

[3] In addition to the countries listed, Austria, Chile, Iceland, Italy, and Romania produced negligible amounts of peat.

[4] Reported figure.

[5] Fiscal year data.

[6] Less than ½ unit.

PERLITE

By Wallace P. Bolen

Domestic survey data and tables were prepared by Maria Arguelles, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2009, the amount of domestic processed crude perlite sold or used and the amount of expanded perlite sold or used both decreased by about 20% compared with that of 2008. Domestic production of processed crude perlite was about 348,000 metric tons (t), and the amount of expanded perlite sold or used was about 439,000 t. Domestically produced processed crude perlite sales declined for the third time in the past 4 years after a brief increase in 2008. The 348,000 t sold or used represent the lowest level of domestic production since 1964, when 318,000 t was produced. The 439,000 t of expanded perlite was the smallest amount sold or used since 1984, when 439,000 t was also recorded in this category.

During the year, imports of processed crude perlite decreased by 18% to 153,000 t compared with that of 2008. This was the third consecutive year with falling perlite imports after a record high import level in 2006. Exports of crude processed perlite were estimated to have been about 33,000 t, decreasing by about 11% compared with those of 2008. Trade data in this report are from the U.S. Census Bureau and the Journal of Commerce's Port Import Export Reporting Service. Percentages in this report were computed using unrounded data.

Production

Domestic production data for perlite were derived by the U.S. Geological Survey (USGS) from two voluntary annual surveys—one for domestic mine operations (processed crude perlite) and one for expanding plants. The expanding plants used domestic and imported processed crude perlite. All the processed crude perlite described in table 1 was produced by seven companies from nine mines, eight of which responded to the USGS survey, representing about 99% of the processed crude perlite sold or used in 2009. According to data collected by the USGS, the 348,000 t of U.S.-processed crude perlite sold or used in 2009 was valued at $17.1 million, a decrease of 18% compared with that of 2008. The 439,000 t of expanded perlite sold or used by domestic producers was valued at $132 million, a decrease of 14% compared with that of 2008 (table 1).

The processed crude perlite reported in table 1 was mined in Arizona, California, Idaho, Nevada, New Mexico, and Oregon. The mines in Arizona, New Mexico, and Oregon accounted for most of the tonnage mined. Ore producers were, in alphabetical order by State, Harborlite Corp. in Arizona and New Mexico; American Perlite Co. in California; Idaho Minerals, LLC in Idaho; EP Minerals, LLC and Wilkins Mining and Trucking, Inc. in Nevada; Dicaperl Minerals Corp. in New Mexico; and Cornerstone Industrial Minerals Corp. in Oregon.

Perlite was expanded at 55 plants throughout the United States and two plants were reported as idle. Of the 55 active plants, 28 plant operators (51%) responded to the USGS survey, representing about 75% of the total expanded perlite sold or used. Production information for nonresponding companies was estimated using previously reported data, with adjustments based on currently reported production trends. The top seven producers of expanded perlite, each with production of more than 20,000 metric tons per year, accounted for about 79% of the expanded perlite sold or used in the United States in 2009. The remaining 21% was produced by 22 companies.

Consumption

In 2009, domestic apparent consumption of processed crude perlite was 468,000 t, a 20% decrease compared with that of 2008. This was the lowest level of apparent consumption since 1983, when 447,000 t of processed crude perlite was consumed. Expanded perlite consumed for construction-related uses, the major market for expanded material, was about 232,000 t, a decrease of 28% compared with that of 2008. Construction uses of expanded perlite, which consisted of concrete aggregate, formed products, masonry- and cavity-fill insulation, and plaster aggregate, accounted for about 53% of total domestic sales of expanded perlite in 2009. Expanded perlite consumption decreased in most markets, with the most pronounced decrease by percentage reported for the formed products market (table 3). Expanded perlite consumption did increase for three of the smaller markets: concrete aggregate, laundries, and low-temperature insulation. Perlite was expanded, usually for local consumption, in 28 States. The leading States in production of expanded perlite sold or used were, in descending order, Illinois, Georgia, Pennsylvania, Mississippi, California, Oregon, Michigan, and Florida. The amount of expanded perlite sold or used by State was listed for those States with three or more companies expanding in each State; for other States, individual data were withheld to avoid disclosing company proprietary data (table 2).

Prices

Processed crude perlite was sold at an average value of $50 per metric ton, which was a slight increase compared with that of 2008. Perlite consumed by expanding plants operated by the mining companies was valued at $47 per ton, which was a 4% increase compared with that of 2008. The average price for all perlite sold or used by mining companies was $49 per ton, which was a slight increase compared with that of 2008. The average price of expanded perlite was $302 per ton, up from $279 per ton in 2008; the range in reported prices, however, was wide—from about $100 to more than $1,000 per ton.

The average price by use of expanded perlite, in descending order, was low-temperature insulation, $559 per ton; fillers, $461 per ton; masonry- and cavity-fill insulation, $459 per ton; horticultural aggregate, $427 per ton; concrete aggregate, $398 per ton; filter aid, $391 per ton; plaster aggregate, $352 per ton; laundries, $247 per ton; and formed products, $195 per ton (table 3).

Foreign Trade

Exports of processed crude and expanded perlite, primarily to Canada, were estimated to be 33,000 t, down by about 11% compared with those of 2008. This decrease was probably related to the decline in demand for horticultural grade perlite. Peat is abundant in Canada, and perlite is commonly mixed with peat and other ingredients to produce potting soils. The Republic of Korea was probably the second largest recipient of U.S. exports, receiving nearly 9,000 t. Besides these 2 countries, perlite was exported to about 20 other countries, but the average amount exported to each country was less than 1,000 t. The value of exports could not be calculated based on available information, but the average prices quoted previously could be applied.

Imports of processed crude perlite, almost exclusively from Greece, decreased by 18% to about 153,000 t compared with those of 2008. S&B Industrial Minerals S.A., Kifissia, Greece, reported in its annual report for 2009 that perlite revenues were down by 18% compared with those of 2008 (S&B Industrial Minerals, S.A., 2010, p. 8). S&B Industrial Minerals was the primary supplier of processed crude perlite imports to the United States. Based on information from the U.S. Census Bureau, the average customs value of perlite imports in 2009 was estimated to be $104 per ton, a decrease of nearly 21% from that of 2008. If insurance and freight costs ($11.51 per ton) were added to the value of the imports, the total average value of imports was $116 per ton, also a decrease of about 21% compared with the total average value in 2008. These decreases in the price of imported perlite were probably in response to decreased fuel costs and an increased availability of ocean transport during 2009. Most imported perlite arrives through the ports of Brunswick, GA; Mobile, AL; Philadelphia, PA; and Wilmington, DE. After arriving at one of these ports, the perlite is shipped to expanding plants throughout the States east of the Mississippi River.

World Review

Based on available information, the United States was estimated to be the leading consumer of processed crude and expanded perlite in 2009. Greece was estimated to have produced about 525,000 t and sold or used the largest amount of perlite among the countries listed in table 4. Other leading producers of processed crude perlite were, in descending order, the United States, Turkey, and Japan. In 2009, 15 countries produced 1.65 million metric tons of perlite, down about 8% compared with global production in 2008. Owing to a lack of reliable information, however, this total does not include all major producing countries, such as China, which was probably the leading or second ranked producer in the world.

Outlook

Total consumption of processed and expanded perlite in the United States in 2010 was expected to remain at the historically low levels of 2009. With the economic recession, which was characterized by lackluster construction activity, including the continuing slump in housing and office construction, the historically low perlite consumption seen in 2009 is expected to continue. Perlite imports in 2010 were expected to be essentially unchanged from 2009 levels. Prices for crude processed perlite increased only slightly in 2009, but prices for expanded perlite increased substantially in 2009. For 2010, prices for crude processed perlite and expanded perlite could remain near 2009 levels because price increases might be difficult to achieve amidst weak demand and strong competition.

Perlite expanding plants, mostly in the Eastern United States, continued to purchase imported perlite and offer strong competition to domestic perlite producers. Imported perlite has supplied about one-third of the demand for processed crude perlite in the United States in 3 of the plast 4 years, and that trend is expected to continue contingent upon the availability and cost of ocean freight. This strong competition from other countries is expected to continue in the coming years as domestic and foreign suppliers fight for market share amidst fluctuating transportation costs, whether rail or ocean freight.

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TABLE 1
PERLITE MINED, PROCESSED, AND EXPANDED IN THE UNITED STATES[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

		2005	2006	2007	2008	2009
Perlite mined[2]		606	516	516	524	304
Processed crude perlite:						
Sold to expanders:						
Quantity		406	360	324	337	263
Value		16,500	15,600	15,000	16,400	13,100
Average value	dollars per metric ton	41	43	46	49	50
Used at own plants to make expanded perlite:						
Quantity		103	95	85	98	85
Value		4,200	3,850	3,550	4,450	4,000
Average value	dollars per metric ton	41	41	42	45	47
Total, sold and used:						
Quantity		508	454	409	434	348
Value		20,700	19,500	18,500	20,800	17,100
Average value	dollars per metric ton	41	43	45	48	49
Expanded perlite:						
Production, quantity		677	646	577	554	450
Sold or used:						
Quantity		677	644	575	548	439
Value		165,000	165,000	155,000	153,000	132,000
Average value	dollars per metric ton	243	256	269	279	302

[1] Data are rounded to no more than three significant digits, except average value; may not add to totals shown.

[2] Crude ore mined and stockpiled for processing.

TABLE 2
EXPANDED PERLITE PRODUCED AND SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

	2008				2009			
		Sold or used				Sold or used		
State	Production, quantity (metric tons)	Quantity (metric tons)	Value (thousands)	Average value[2] (dollars per metric ton)	Production, quantity (metric tons)	Quantity (metric tons)	Value (thousands)	Average value[2] (dollars per metric ton)
California	33,200	33,000	$11,700	353	29,100	28,700	$10,800	376
Florida	25,600	25,300	7,470	295	21,300	21,000	7,120	338
Indiana	16,000	15,800	5,700	359	12,900	12,800	4,710	369
Michigan	21,700	21,700	5,750	265	21,800	21,200	5,460	258
Nevada	10,900	10,900	4,890	450	11,100	11,100	4,980	448
Pennsylvania	52,700	52,700	11,800	224	47,700	47,700	11,200	235
Other[3]	393,000	389,000	106,000	272	306,000	296,000	88,100	292
Total or average	554,000	548,000	153,000	279	450,000	439,000	132,000	302

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Average value is based on unrounded data and is rounded to the nearest dollar.

[3] Includes Alabama, Arizona, Arkansas, Colorado, Georgia, Idaho, Illinois, Louisiana, Maine, Massachusetts, Minnesota, Mississippi, Missouri, New Jersey, North Carolina, Ohio, Oklahoma, Oregon, Tennessee, Texas, Wisconsin, and Wyoming.

TABLE 3

EXPANDED PERLITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

Use	2008 Quantity (metric tons)	2008 Value (thousands)	2008 Average value[2] (dollars per metric ton)	2009 Quantity (metric tons)	2009 Value (thousands)	2009 Average value[2] (dollars per metric ton)
Concrete aggregate	2,400	$836	348	2,440	$973	398
Fillers	68,800	32,100	467	62,700	28,900	461
Filter aid	44,200	16,900	383	37,200	14,500	391
Formed products[3]	310,000	57,800	186	222,000	43,200	195
Horticultural aggregate	71,400	27,100	380	63,600	27,100	427
Laundries	832	246	295	1,020	251	247
Low-temperature insulation	1,600	845	527	1,990	1,110	559
Masonry- and cavity-fill insulation	3,090	1,350	438	2,600	1,190	459
Plaster aggregate	5,400	1,800	333	4,880	1,720	352
Other[4]	40,400	14,100	348	40,000	13,400	334
Total or average	548,000	153,000	279	439,000	132,000	302

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Average value is based on unrounded data and is rounded to the nearest dollar.

[3] Includes acoustic ceiling panels, pipe insulation, roof insulation board, and unspecified formed products.

[4] Includes explosives, high-temperature insulation, paint, refractory, soap, steel, sugar manufacture, and unspecified uses.

TABLE 4

PERLITE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009
Armenia	35,000	35,000	35,000	35,000	35,000
Australia[4]	6,000	6,500	7,000	7,000	6,500
Georgia	45,000	45,000	45,000	45,000	45,000
Greece[5]	525,000	525,000	525,000	525,000	525,000
Hungary[4]	65,000	71,000	67,000	67,000 [r]	65,000
Iran	31,000	40,000	30,000	30,000	30,000
Italy	60,000	60,000	60,000	60,000	60,000
Japan	240,000	240,000	230,000	230,000	220,000
Mexico[4]	91,724 [6]	41,219 [6]	41,000	54,405 [6]	54,400
Philippines	4,410 [6]	4,352 [6]	4,515 [6]	4,593 [r, 6]	4,600
Slovakia	13,000	16,000 [r]	20,000	25,000 [r]	25,000
South Africa	400	400	400	400	400
Turkey[4]	156,935 [6]	260,000	270,000	270,000	230,000
United States[7]	508,000 [6]	454,000 [6]	409,000 [6]	434,000 [6]	348,000 [6]
Zimbabwe	4,000	3,000	3,000	3,000	3,000
Total	1,790,000	1,800,000 [r]	1,750,000	1,790,000	1,650,000

[r] Revised.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Unless otherwise stated, figures represent processed ore output. Table contains data available through May 12, 2010.

[3] In addition to the countries listed, Djibouti started perlite production in 2009, and Algeria, Bulgaria, China, Cyprus, Iceland, Morocco, Mozambique, and Russia are thought to have produced perlite, but output is not reported, and available information is inadequate to estimate output.

[4] Crude ore.

[5] Crude perlite screened and sold.

[6] Reported figure.

[7] Processed ore sold and used by producers.

PHOSPHATE ROCK

By Stephen M. Jasinski

Domestic survey data and tables were prepared by Raymond I. Eldridge III, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

Domestic phosphate rock production in 2009 was 26.4 million metric tons (Mt) compared with 30.2 Mt in 2008, and reported use of phosphate rock was 25.5 Mt compared with 28.9 Mt in 2008 (tables 1, 3–4). World production was slightly higher than that in 2008 (table 10), owing to increased production in China. In 2009, the world phosphate market, except for China, was affected by the world economic downturn, low demand for fertilizers, and high inventories of phosphate rock and fertilizers. In the United States, phosphate rock production and reported use were at their lowest levels since 1964, and apparent consumption was the lowest since 1972. Market conditions improved slightly in the last quarter of the year as production and consumption of phosphate rock and fertilizers increased.

Phosphorus is an essential element for plant and animal nutrition and is consumed primarily as a principal component of nitrogen-phosphorus-potassium (NPK) fertilizers. Phosphate rock minerals are the only significant global resources of phosphorus. In this report (unless noted otherwise), mine production is reported in terms of marketable production, which refers to beneficiated phosphate rock with a suitable phosphorus pentoxide (P_2O_5) content for wet-process phosphoric acid or elemental phosphorus manufacturing. Quantities are reported in metric units and percentages have been calculated using unrounded data.

In 2009, phosphate rock was produced at seven mines in Florida, three in Idaho, and one each in North Carolina and Utah (table 2).

Domestic production of all types of phosphoric acid in 2009 decreased to 8.66 Mt P_2O_5 from 9.22 Mt P_2O_5 in 2008. Combined production of all types of phosphate fertilizers was slightly higher than in 2008 because of increased production of diammonium phosphate (DAP) (U.S. Census Bureau, 2010). The major fertilizer products manufactured from phosphoric acid were DAP and monoammonium phosphate (MAP).

Production

U.S. Geological Survey domestic phosphate rock production data were obtained from monthly and semiannual voluntary canvasses of all companies that owned phosphate rock mines. All companies responded to the canvass in 2009. During the year, 12 phosphate rock mines were active (table 2).

The U.S. phosphate industry is concentrated in Florida in the counties of Hamilton, Hardee, Hillsborough, Manatee, and Polk. In 2009, seven mines, representing 65% of domestic annual production capacity, were active in Florida. The Mosaic Company, operated five mines, and CF Industries, Inc. and PCS Phosphate Co., Inc. each operated one (table 2).

In Beaufort County, NC, PCS operated a large integrated production facility that included a mine, as well as animal feed, fertilizer, and phosphoric acid plants.

In the Western Phosphate Field in Idaho, Montana, Utah, and Wyoming, four mines were active in 2009—three in Idaho, and one in Utah (table 2). In Idaho, phosphate rock was mined in Caribou County by Nu-West Industries, Inc. (a subsidiary of Agrium Inc., Calgary, Alberta, Canada), P4 Production, L.L.C. (a subsidiary of Monsanto Co.), and J.R. Simplot Co. Simplot also operated the Vernal Mine in Uintah County, UT.

In Idaho, all three producers, Agrium, P4 Production, and Simplot began development of new mines as replacements for their current mines when the mines are exhausted.

Consumption

Phosphate rock was used primarily for production of wet-process phosphoric acid for fertilizer applications, which accounted for more than 95% of domestic consumption. The remainder was used in the manufacturing of animal feed supplements, for direct application to soil, and for elemental phosphorus production. Domestic consumption of phosphate rock decreased to 27.5 Mt compared with 31.6 Mt in 2008 (table 1), owing to lower phosphoric acid production. There were no sales of domestically mined phosphate rock reported by producers. Consumption by grade and by region was withheld from publication to avoid disclosing company proprietary information.

All phosphate rock mining companies are vertically integrated with one or more fertilizer plants, usually located near the mine. Mosaic is the leading company with about 56% of domestic phosphoric acid production capacity and 13% of world capacity. In 2009, the company operated four wet process phosphoric acid plants and four fertilizer plants in Florida and one of each in Louisiana (Mosaic Company, The, 2010, p. 1).

PCS had phosphoric acid and fertilizer production facilities near its mines in Florida and North Carolina. In Idaho, Simplot sent ore from its Smoky Canyon Mine by slurry pipeline to its fertilizer plant in Pocatello, ID; Simplot sent ore from the Vernal Mine in Utah to its plant in Rock Springs, WY.

Three companies—Agrifos Fertilizer Inc., Pasadena, TX; Mississippi Phosphates Corp., Pascagoula, MS; and PCS Nitrogen, Inc., Geismar, LA—manufactured wet-process phosphoric acid using imported phosphate rock from Morocco. Agrifos and Mississippi Phosphates produced phosphate fertilizer products for domestic and export markets. PCS sold some merchant-grade phosphoric acid to Innophos Holdings, Inc., which had a nearby facility, for upgrading into high-purity acid for technical- and food-grade applications (Innophos Holdings, Inc., 2010, p. 7).

Monsanto operated the only elemental phosphorus plant in the United States in Soda Springs, ID. The company used elemental phosphorus primarily to manufacture phosphorus trichloride, which was used as a chemical intermediary for the production of glyphosate-base herbicides (Monsanto Company, 2009, p. 9). In other countries, elemental phosphorus is used chiefly to manufacture high-purity phosphoric acid by burning the phosphorus in water, which is known as thermal acid. Worldwide, there has been a gradual shift to manufacturing high-purity phosphoric acid from wet-process acid, which has lower operating costs and none of the hazardous waste disposal issues that are associated with elemental phosphorus. Thermal acid, however, still accounts for 65% of annual world production capacity of high-purity phosphoric acid. China was the leading producer of elemental phosphorus in the world with about 45 companies, most producing less than 10,000 metric tons per year of P_2O_5 (Jiang, 2006). The only other operating elemental phosphorus facilities in the world were thought to be located in Kazakhstan and the Netherlands.

The United States is considered a mature market for phosphate fertilizers, with average annual consumption of slightly more than 4 Mt during the past decade. Fertilizer consumption information is collected by the American Association of Plant Food Officials on a crop year (July 1 to June 30) basis. The most recent data, for crop year 2008 (July 1, 2007 to June 30, 2008), showed a 10% drop in P_2O_5 consumed in fertilizers from the previous crop year (Slater and Kirby, 2010). Consumption of P_2O_5 contained in fertilizers was estimated to have decreased again in crop year 2009.

Stocks

Producers' stocks of phosphate rock in 2009 were 28% higher than those of 2008 owing to lower consumption. Regional data were consolidated to avoid disclosing company proprietary information (table 3).

Transportation

In Florida and North Carolina, crude phosphate rock ore was sent by slurry pipeline from the mines to the processing plants. All beneficiated phosphate rock was used internally to manufacture wet-process phosphoric acid; the beneficiated phosphate rock was sent by conveyers to acid plants. Mosaic sent beneficiated phosphate rock by rail to the Port of Tampa and ore by barge across the Gulf of Mexico to its facilities in Louisiana. In central Florida, animal feed products, fertilizers, and phosphoric acid were sent by rail to domestic customers or to the Port of Tampa for export. The Port of Tampa handles the largest volume of fertilizer materials in the United States (Wainio, 2009).

In northern Florida, PCS transported its fertilizer products by rail to consumers; some materials, however, were sent by rail to the PCS port facility at Morehead City, NC, for export. PCS used barges and tugboats to move products from its Aurora, NC, complex to the Port of Morehead City for export or delivery by rail to domestic consumers (Potash Corporation of Saskatchewan Inc., 2010, p. 18). Phosphoric acid producers along the Gulf of Mexico received phosphate rock by ship from Morocco and transported their products by barge on the Mississippi River and its tributaries or by rail to domestic consumers. In Idaho and Utah, phosphate rock was sent from the mine to the processing facility via truck, rail, and slurry pipelines.

Prices

Price data were collected through the semiannual canvass of producers and reflected the value of phosphate rock used for production of phosphoric acid and elemental phosphorus. The total value of phosphate rock used in the United States increased by 45% over that of 2008, owing to a large increase in regional values in the first half of the year. The average value increased to \$127.22 per metric ton in 2009 from \$76.64 per ton in 2008 (table 1). Unlike many other mineral commodities, no standard domestic or world price for phosphate rock exists. Average ranges of world prices were published in various industry trade journals based on a sample of transactions. The import price of \$80.61 per ton was determined based on the U.S. Census Bureau customs value and included cost, insurance, and freight (table 1).

Foreign Trade

U.S. producers reported no exports of phosphate rock in 2009 (table 1). The United States is the leading importer of phosphate rock in the world. Most of the shipments from Morocco were consumed by the three phosphoric acid producers located along the Gulf of Mexico. The remainder of Moroccan imports was consumed by Mosaic at its plants in Florida and Louisiana (Mosaic Company, The, 2010, p. 7). In 2009, U.S. imports were estimated to be 2.0 Mt, based on U.S. Census Bureau data and export information received from OCP Group, the Moroccan phosphate producer (Benzekri, Mohammed, OCP Group, written commun., July 22, 2009). Tonnage and value information for some phosphate rock and fertilizer product shipments were underreported by the U.S. Census Bureau, which necessitated the use of other sources. U.S. import tonnage of other phosphate fertilizers were insignificant compared with exports of the same materials (tables 5–7, and 9).

Exports of elemental phosphorus increased to 17,300 t in 2009 from 12,900 t in 2008. The average unit value increased to \$3,820 per ton in 2009 from \$3,660 per ton in 2008 (table 8).

The United States is the leading exporter of phosphate fertilizers in the world, accounting for about 30% of world P_2O_5 exports in 2009. In 2009, total exports of phosphoric acid and phosphate fertilizers increased by 2%, in terms of P_2O_5 content (U.S. Census Bureau, 2010). India was the leading destination for U.S. phosphate exports (tables 5–7).

World Review

World production of phosphate rock in 2009 increased slightly compared with that of 2008. China (60.2 Mt), the United States (26.4 Mt), and Morocco (23.0 Mt) were the leading producing countries, accounting for 66% of the world total (table 10). Phosphate rock production in China likely was higher than the official figure of 60.2 Mt, which did not include production from numerous, small independent mines. Information was not available to estimate production from these operations.

Australia.—Minemakers Ltd. progressed in the development of its Wonarah phosphate rock mine in the Northern Territory of Australia. The deposit has an inferred phosphate rock resource of 1,100 Mt with an average grade of 18% P_2O_5. The firm plans to ship the phosphate rock from the Port of Darwin to destinations in Asia and New Zealand (Drummond, 2010).

Mali.—Two companies began exploration of separate phosphate rock deposits in Mali. Oklo Uranium Ltd. of Australia was developing the Tatteul deposit in northeastern Mali. The company expected to start production in 2012 (Industrial Minerals, 2009b). Great Quest Metals Ltd. of Canada began exploration of the Tin Hina deposit in the Tilemsi Valley in northeastern Mali near the border with Niger. The firm claimed potential resources of more than 50 Mt of phosphate rock. The deposit is located near the Tamaguillelt phosphate rock deposit, from which phosphate rock was produced from the late 1970s to the early 1990s. Great Quest was not planning to acquire the Tamaguillelt deposit or closed phosphate plant in Bourem (Industrial Minerals, 2009a).

Morocco.—OCP Group, the Moroccan phosphate rock producer, announced plans to expand its phosphate rock production capacity from 28 Mt/yr to 54 Mt/yr by 2015. The company plans to develop three new mines and build a slurry pipeline to transport ore from the mines to the processing plant (Bakr, 2009).

Namibia.—Minemakers Ltd. gained controlling interest in the Sandpiper/Meob offshore phosphate deposit after its acquisition of Bonaparte Diamond Mines NL and another Australian company, Union Resources Ltd. Minemakers other partner in the project was Tungeni Investments CC, a Namibian firm. The phosphate deposits were about 100 kilometers off the coast of Namibia and contained an estimated indicated resource of 47.6 Mt grading 21.4% P_2O_5 and estimated inferred resources of 1.41 billion metric tons grading 18.8% P_2O_5 according to Minemakers (Drummond, 2010).

Outlook

The phosphate industry was expected to recover gradually from the effects of the world financial downturn through 2010. World production of phosphate rock, phosphoric acid, and fertilizers was projected to increase slightly in 2010, following the depressed conditions in 2009. Between 2009 and 2014, world phosphate rock annual production capacity is projected to increase from 190 Mt to 228 Mt, from new mines and expansions at existing mines (Heffer and Prud'homme, 2010). New mines were planned for Australia, Brazil, Kazakhstan, Namibia, Peru, and Russia. Mine expansions were planned in Algeria, China, Jordan, Morocco, Tunisia, and Vietnam. About one-half the new production will be available for sale on the world market.

Phosphate rock production in North America was projected to drop slightly during the next 5 years owing to mine depletions in Florida and Canada. Four new mines are in various stages of permitting in Florida to replace existing mines; the permitting process, however, has extended for several years because of opposition to mine expansion by counties located south of the planned new mines over water management and pollution issues. In Idaho, two new mines are planned to replace existing mines in the next 5 years; both were well into the permitting process in 2009.

World consumption of phosphate contained in fertilizers was projected to increase by about 7% in 2010, after the poor economic conditions in 2009, and then increase by 3% annually through 2014, according to IFA (Heffer and Prud'homme, 2010). U.S. fertilizer consumption was expected to rebound by more than 5% in 2010 based on preliminary data of U.S. phosphoric acid and fertilizer production.

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TABLE 1

SALIENT PHOSPHATE ROCK STATISTICS[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

		2005	2006	2007	2008	2009
United States:						
Mine production (crude ore)		151,000	111,000	126,000	124,000	107,000
Marketable production:						
Quantity:						
Gross weight		36,100	30,100	29,700	30,200	26,400
P_2O_5 content		10,300	8,680	8,480	8,590	7,640
Value		1,070,000	919,000	1,520,000	2,320,000	3,360,000
Value, average[2]	dollars per metric ton	29.61	30.49	51.10	76.76	127.19
Sold or used by producers:						
Quantity:						
Gross weight		35,200	30,200	31,100	28,900	25,500
P_2O_5 content		10,200	8,710	8,890	8,200	7,380
Value		1,040,000	922,000	1,600,000	2,210,000	3,250,000
Value, average	dollars per metric ton	29.60	30.52	51.36	76.64	127.22
Imports for consumption[e, 3, 4]						
Quantity, gross weight		2,630	2,420	2,670	2,750	2,000
Value, cost, insurance, and freight[e]		107,000	115,000	154,000	266,000	161,000
Value, average	dollars per metric ton	40.91	47.52	57.54	96.95	80.61
Consumption, gross weight[e, 5]		37,800	32,600	33,500	31,600	27,500
Stocks, December 31, producers		6,970	7,070	4,970	6,340	8,120
World, production, gross weight		152,000 [r]	151,000 [r]	160,000 [r]	165,000 [r]	166,000

[e]Estimated. [r]Revised.

[1] Data are rounded to no more than three significant digits, except average values per metric ton.

[2] Average value based on the sold or used values.

[3] Source: U.S. Census Bureau.

[4] Includes some estimated phosphate rock tonnage imported from Morocco but not reported by the U.S. Census Bureau.

[5] Expressed as sold or used plus imports.

TABLE 2

ACTIVE PHOSPHATE ROCK MINES IN THE UNITED STATES IN 2009

Owner	Mine	County and State
CF Industries Holdings, Inc.	South Pasture	Hardee, FL.
Mosaic Company, The	Four Corners	Hillsborough/Manatee/Polk, FL.
Do.	Hookers Prairie	Polk, FL.
Do.	Hopewell	Hillsborough, FL.
Do.	South Fort Meade	Polk, FL.
Do.	Wingate	Manatee, FL.
Nu-West Industries, Inc. (Agrium Inc.)	Dry Valley	Caribou, ID.
P4 Production, LLC. (Monsanto Co.)	South Rasmussen	Do.
PCS Phosphate Co., Inc.	Aurora	Beaufort, NC.
Do.	Swift Creek	Hamilton, FL.
Simplot, J.R., Co.	Smoky Canyon	Caribou, ID.
Do.	Vernal	Uintah, UT.

Do. Ditto.

TABLE 3

PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES, BY PERIOD[1]

(Thousand metric tons and thousand dollars)

	Mine production, crude ore		Marketable production, beneficiated			
Period	Rock	P_2O_5 content	Rock	P_2O_5 content	Value[2]	Ending stocks, rock
2008:						
January–June	63,400	6,360	15,300	4,370	1,730,000	4,890
July–December	61,100	6,000	14,900	4,220	585,000	6,340
Total	124,000	12,400	30,200	8,590	2,320,000	XX
2009:						
January–June	53,800	5,430	12,900	3,730	2,500,000	9,100
July–December	53,200	5,470	13,500	3,910	858,000	8,120
Total	107,000	10,900	26,400	7,640	3,360,000	XX

XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Based on the per ton sold or used values.

TABLE 4
PHOSPHATE ROCK SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY PERIOD[1]

(Thousand metric tons and thousand dollars)

Period	Rock	P_2O_5 content	Value[2]
2008:			
January–June	15,300	4,360	1,640,000
July–December	13,500	3,840	574,000
Total	28,900	8,200	2,210,000
2009:			
January–June	11,200	3,230	2,310,000
July–December	14,300	4,150	936,000
Total	25,500	7,380	3,250,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free on board mine.

TABLE 5
U.S. EXPORTS OF DIAMMONIUM PHOSPHATE[1, 2]

(Thousand metric tons and thousand dollars)

Country	2008 Quantity	2008 Value	2009 Quantity	2009 Value
Argentina	112	76,800	88	32,300
Brazil	177	173,000	144	35,200
China	--	--	348	106,000
India	2,890	2,660,000	3,210	1,030,000
Japan	281	265,000	162	51,200
Kenya	30	10,500	150	100,000
Mexico	188	119,000	208	68,600
Pakistan	--	--	146	45,000
Peru	87	62,700	136	40,400
Vietnam	--	--	196	66,900
Other	713 [r]	462,000 [r]	743	244,000
Total	4,530	3,890,000	5,530	1,820,000

[r] Revised. -- Zero.

[1] Presentation of annual data is based on the top 10 quantities (gross weight) of the leading countries in 2009.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 6
U.S. EXPORTS OF MONOAMMONIUM PHOSPHATE[1, 2]

(Thousand metric tons and thousand dollars)

Country	2008		2009	
	Quantity	Value	Quantity	Value
Argentina	76	81,300	231	68,500
Australia	325	307,000	257	90,300
Brazil	228	248,000	495	158,000
Canada	1,220	359,000	601	196,000
Chile	75	75,100	46	14,000
Colombia	78	77,100	92	29,100
India	104	115,000	43	36,000
Japan	121	122,000	64	20,700
Mexico	139	85,200	106	35,900
Uruguay	--	--	43	11,900
Other	123 [r]	108,000 [r]	130	57,000
Total	2,490	1,580,000	2,110	717,000

[r] Revised. -- Zero.

[1] Presentation of annual data is based on the top 10 quantities (gross weight) of the leading countries in 2009.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 7
U.S. EXPORTS OF PHOSPHORIC ACID[1]

(Thousand metric tons and thousand dollars)

Country	2008		2009	
	Quantity	Value	Quantity	Value
Brazil	34	18,900	35	16,400
Canada	13	3,970	29	8,400
India	366	228,000	404	96,800
Mexico	65	19,300	60	18,000
Other	31	12,100	7	2,820
Total	510	282,000	535	142,000

[1] Excludes superphosphoric acid tonnage.

Source: U.S. Census Bureau.

TABLE 8

U.S. EXPORTS OF ELEMENTAL PHOSPHORUS[1]

Country	2008		2009	
	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Brazil	10,800	42,500	14,300	58,900
Canada	1,770	3,900	1,270	3,640
Mexico	30	61	517	995
Other	315	745	1,250	2,500
Total	12,900	47,200	17,300	66,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship values.

Source: U.S. Census Bureau.

TABLE 9

U.S. IMPORTS FOR CONSUMPTION OF PHOSPHATE ROCK AND PHOSPHATIC MATERIALS[1]

(Thousand metric tons and thousand dollars)

Phosphatic materials	2008		2009	
	Quantity	Value[2]	Quantity	Value[2]
Phosphate rock:				
Unground[3]	1,350	145,000	988	83,100
Ground[3]	488	32,900	379	26,900
Total[4]	2,750	266,000	2,000	161,000
Dicalcium phosphate	8	14,200	6	11,200
Elemental phosphorus	8	54,300	4	15,600
Normal superphosphate	2	484	(5)	114
Triple superphosphate	163	123,000	38	9,340
Diammonium phosphate	31	13,400	22	9,710
Fertilizer containing nitrates and phosphates	1	645	1	492
Phosphoric acid	49	41,900	31	30,600

[1] Data are rounded to no more than three significant digits.

[2] Declared cost, insurance, freight values.

[3] Some phosphate rock tonnages and values were suppressed by the U.S. Census Bureau.

[4] Includes an estimate for data suppressed by U.S. Census Bureau based on reported Moroccan exports to the United States.

[5] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 10

PHOSPHATE ROCK, BASIC SLAG, AND GUANO: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

	Gross weight					P_2O_5 content				
Commodity and country[3]	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009
Phosphate rock:										
Algeria	878	1,510	1,800	1,805 [r]	1,800 [e]	260	450	536	542 [r]	540 [e]
Australia	2,700	2,750	2,850	2,950 [r, e]	2,800	760	770	655 [r]	678 [r]	643
Brazil, concentrate	5,631	5,932	6,185	6,343 [r]	6,350	2,050	2,111	2,185	2,242 [r]	2,250
Burkina Faso[e]	2	2	2	2	2	1	1	1	1	1
Canada[e]	800 [r]	500 [r]	700	700 [r]	700	270 [r]	165 [r]	210 [r]	210 [r]	200
Chile, phosphate rock and phosphorite[4]	20	14	25	38	35	5	4	6	10	9
China	30,400	38,600	45,400	50,700	60,200	9,130	11,600	15,100	15,200	18,000
Colombia[e]	43	43	43	27 [r]	30	8	8	8	8 [r]	8
Egypt, beneficiated	3,371 [r]	2,177 [r]	3,890 [r]	5,523 [r]	5,000 [e]	1,011 [r]	653 [r]	1,167 [r]	1,657 [r]	1,500 [e]
Finland[e]	825	825	825	825	825	301	300	300	300	300
India[e]	1,200	1,200	1,210	1,220	1,230	355	355	358	631	640
Indonesia[e]	1	1	1	1	1	(5)	(5)	(5)	(5)	(5)
Iran[e]	324 [6]	325 [6]	330	325	330	40	40	41	36 [r]	40
Iraq, beneficiated[e]	1	1	1	10	30	(5)	(5)	(5)	3	10
Israel	3,236	2,949	3,069	3,088	2,697	890 [e]	810 [e]	840 [e]	850 [e]	740 [e]
Jordan	6,375	5,805	5,552	6,265	5,281	2,040	1,860	1,780	2,005	1,620
Kazakhstan	800 [r]	845 [r]	720 [r]	1,226 [r]	1,225	175 [r]	195 [r]	165 [r]	280 [r]	280 [e]
Korea, North[e]	300	300	300	300	300	95	95	95	95	95
Mexico	(5)	8	42 [r]	968 [r]	1,443	(5)	2	14 [r]	291 [r]	433
Morocco[e, 7]	28,788	27,400 [r]	27,800 [r]	24,500 [r]	23,000 [e]	9,195	8,700 [r]	8,900 [r]	7,850 [r]	7,360 [e]
Nauru[e]	8	45	45	45	45	3	17	17	17	17
Pakistan	3	2	2 [e]	2 [e]	2 [e]	(5)	(5)	(5) [e]	(5) [e]	(5) [e]
Peru[e]	47 [r]	38	57 [r]	38	38	14	11 [r]	17 [6]	11 [r]	11
Philippines	2	2	2	2	2 [e]	1 [e]	1 [e]	1 [e]	1 [e]	1 [e]
Russia[e]	11,000	11,000	11,400	10,400	10,000	4,000	4,000	4,200	3,800	3,650
Senegal	1,455	584	691	645 [r]	650 [e]	504	180	234	180 [r]	200 [e]
South Africa	2,577	2,629	2,556	2,287	2,237	941	960	933	830 [e]	810 [e]
Sri Lanka[e]	43	42 [r, 6]	40 [r, 6]	40 [r]	40	15	15	15	15	15
Syria	3,500	3,664	3,678 [r]	3,221	2,466	1,080 [e]	1,130 [e]	1,140 [e]	993	1,030 [e]
Tanzania	7	3	8	8 [e]	8 [e]	2	1	3	3 [e]	3 [e]
Thailand	3	1	4	4 [r]	4 [e]	1 [e]	(5) [e]	1 [r, e]	1 [r, e]	1 [e]
Togo	1,350	1,650	750	842 [r]	850 [e]	481 [e]	590 [e]	270 [e]	303 [r, e]	300 [e]
Tunisia, washed	8,220	7,801	8,005	7,623 [r]	7,398	2,400 [e]	2,300 [e]	2,400 [r, e]	2,300 [e]	2,200 [e]
United States	36,100	30,100	29,700	30,200	26,400	10,300	8,680	8,480	8,590	7,640
Uzbekistan[e]	430	600	600	600	600	102 [6]	140	140	140	140
Venezuela[e]	392 [6]	400	400	400	400	110	115	115 [r]	115 [r]	115
Vietnam	1,024 [r]	1,232 [r]	1,523 [r]	2,099 [r]	2,000 [e]	320	365	390	600 [r]	600 [e]
Zimbabwe, concentrate[e]	46 [6]	66 [6]	30	30	30	15	21	10	10	10
Total	152,000 [r]	151,000 [r]	160,000 [r]	165,000 [r]	166,000	46,900 [r]	46,600 [r]	50,700 [r]	50,800 [r]	51,400

See footnotes at end of table.

TABLE 10—Continued

PHOSPHATE ROCK, BASIC SLAG, AND GUANO: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

	Gross weight					P_2O_5 content				
Commodity and country[3]	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009
Basic (Thomas converter) slag:[e]										
Egypt	7	8	8	8	8	2	2	2	2	2
France	50	50	50	50	50	8	8	8	8	8
Luxembourg	450	475	475	475	475	70	70	70	70	70
Total	507	533	533	533	533	80	80	80	80	80

[e] Estimated. [r] Revised.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 14, 2010. Figures are from official country sources where available.

[3] In addition to the commodities listed, phosphate rock may be produced in Nigeria, but information is inadequate to estimate output.

[4] In 2008, Chile produced 2,892 metric tons (gross weight) of guano in addition to apatite and phosphorite. P_2O_5 content for these commodities are not available.

[5] Less than ½ unit.

[6] Reported figure.

[7] Includes production from Western Sahara.

PLATINUM-GROUP METALS

By Patricia J. Loferski

Domestic survey data and tables were prepared by Pamela A. Wiser, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2009, Stillwater Mining Co. (SMC) (Billings, MT) was the only domestic mine producer of platinum-group metals (PGMs) from its Stillwater Mine near Nye, MT, and its East Boulder Mine south of Big Timber, MT. OJSC MMC Norilsk Nickel (Moscow, Russia) was the majority owner of SMC. SMC produced 16,500 kilograms (kg) of platinum and palladium in 2009, 6% more than the 15,500 kg that was produced in 2008 (Stillwater Mining Co., 2010, p. 46–47). Defense National Stockpile Center reported no PGM sales in 2009; 18 kg of iridium and 261 kg of platinum remained in the stockpile. Palladium stocks were exhausted in 2004 (table 1).

In 2009, the automobile industry continued to be a major consumer of PGMs. Autocatalysts accounted for approximately 82% of rhodium consumption, 45% of palladium consumption, and 23% of platinum consumption on a global basis. Jewelry was the leading use of platinum in 2009, at 48% of global consumption, up from 30% in 2008. The growth in jewelry consumption was largely fueled by increased consumption in China (Jollie, 2010, p. 28, 54–59).

Production

Primary.—During 2009, the Stillwater Mine produced 9,390 kg of palladium and 2,860 kg of platinum, 13% and 14% more, respectively, relative to production in 2008. PGM production from the East Boulder Mine was 4,230 kg (3,270 kg of palladium and 964 kg of platinum), which was a 9% decrease in both palladium and platinum production compared with that of 2008. Palladium and platinum production for SMC increased by 6% and 7%, respectively, compared with production in 2008. Production of rhodium in 2009 was 124 kg, which was double the amount of production in 2008 (Stillwater Mining Co., 2010, p. 47). The company milled 1.09 million metric tons (Mt) of ore from the mines, a 2% increase relative to that of 2008. The increased production was attributed to restructuring of mine operations in 2008. Operations at the smaller East Boulder Mine were halted for several weeks, and the workforce was downsized, with a portion of the workforce reassigned to the higher grade Stillwater Mine, replacing higher cost contract workers. Despite a 27% decrease in personnel, overall productivity improved significantly. The Stillwater and East Boulder Mines improved their mining efficiency in terms of tons mined per employee-hour by 21% and 50%, respectively, in 2009 relative to that of 2008.

Stillwater had a sales agreement with General Motors Corp. (GM) (Detroit, MI) to supply PGMs for use in automobile catalytic converters; however, the contract was nullified in July as part of GM's bankruptcy proceedings. Stillwater's PGM sales agreement with Ford Motor Co. (Dearborn, MI) was set to expire at yearend 2010.

Stillwater constructed and commissioned a second electric furnace, which was fully operational by the end of the second quarter 2009 and was capable of processing up to 50% more concentrate than the original furnace. The new furnace was part of the company's plan to expand the capacity of its recycling business by sourcing additional supplies of spent catalytic converters.

At yearend 2009, the company reported proven and probable reserves of 641,000 kg of palladium and platinum, with an average grade of 15.6 grams per metric ton (g/t) and with an in situ palladium to platinum ratio of about 3.4 to 1 at the Stillwater Mine and 3.5 to 1 at the East Boulder Mine. Average mill head grades ranged from 17.4 g/t at the Stillwater Mine to 11.8 g/t at the East Boulder Mine. SMC's proven and probable reserves of PGMs are contained in the J-M Reef, an ore body within the layered mafic and ultramafic igneous rocks of the Stillwater Complex. SMC planned to produce 16,000 kg of PGMs in 2010 (Stillwater Mining Co., 2010, p. 10, 12).

In 2009, PGM exploration continued at several locations in the United States. The most advanced project was PolyMet Mining Corp.'s (Hoyt Lakes, MN) NorthMet Mine in the Duluth Complex in northeast Minnesota. In early November, PolyMet published its draft environmental impact statement (EIS) from the Minnesota Department of Natural Resources and began a 90-day public comment period, which was to end in early February 2010. The draft EIS provided an extensive review of the potential environmental impacts of restarting the nearby Erie crushing and milling complex, initially built to process iron ore, which the company purchased in 2005. The draft EIS also addressed the impact of proposed new metallurgical facilities at the plant site and development of the NorthMet open pit mine (PolyMet Mining Corp., 2010, p. 2). Franconia Minerals Corp. (Spokane Valley, WA) planned to begin a prefeasibility study of its Birch Lake project, also in the Duluth Complex. The prefeasibility study was expected to be completed in 2010 (Franconia Minerals Corp., 2010, p. 3). In Alaska, Pure Nickel, Inc. (Toronto, Ontario, Canada) continued exploration of the nickel-copper-cobalt-PGM MAN property 265 kilometers (km) south-southeast of Fairbanks. Pure Nickel completed 4,200 meters of drilling as well as a geophysical program in 2009. The company partnered with ITOCHU Corp. (Tokyo, Japan) to advance the MAN project (Pure Nickel, Inc., 2010, p. 3).

Secondary.—In 2009, PGMs were recycled from three main sources—autocatalysts, electronics, and jewelry. The global recovery of platinum from recycling of autocatalysts decreased by 27% in 2009 compared with that of 2008, reaching 25,800 kg. In North America, recovery of platinum from catalytic converters was an estimated 13,200 kg of platinum, which was a 32% decrease compared with that in 2008, and represented roughly 51% of global autocatalyst recycled material. Recovery of platinum from catalytic converters decreased by 25% and 17% in Europe and Japan, respectively, and increased by 33% in China compared with 2008 quantities. In the rest of the world, recycling of autocatalysts produced about the same amount of platinum in 2009 as compared with that of 2008. Globally, recycling of autocatalysts decreased sharply in the first half of 2009 as a result of the drop in metal prices, but picked up in the second half of 2009 as prices increased. About 311 kg of platinum was recovered from electronics recycling in 2009, which was double the amount recovered in 2008. About 17,600 kg of platinum was recovered from the jewelry industry globally, a decrease of 19% compared with that of 2008 (Jollie, 2010, p. 24).

About 30,000 kg of palladium was recovered from autocatalysts globally in 2009, a decrease of 15% compared with that of 2008. Roughly 56% of global recycled palladium came from North America. Palladium recovery from autocatalysts in North America decreased by 19% to 16,800 kg, and that in Europe decreased by 10% to 8,710 kg relative to that in 2008. Palladium recovery from autocatalysts in Japan decreased by 29% and that in China increased by 17% compared with levels in 2008. Recycling of palladium from electronics totaled 12,300 kg in 2009, an increase of 14% compared with that of 2008. Recycling of palladium from the jewelry industry totaled about 2,180 kg in 2009, which was about 46% less than that of 2008. In 2009, global recovery of rhodium from autocatalysts decreased by 18% to 5,820 kg (Jollie, 2010, p. 24).

SMC's recycling program recovered 7,810 kg of PGMs in 2009, a decrease of 37% as compared with that of 2008. The sale of the recycled material was $81.8 million in 2009, which was down by 83% from the 2008 sales value because of lower prices in the first half of 2009 (Stillwater Mining Co., 2010, p. 21).

Consumption

In 2009, global platinum sales totaled 193,000 kg, a 9% decrease compared with sales in 2008. About 48% of the total was consumed by the jewelry industry, about 23% by the autocatalyst industry, and about 11% was used as investment. The remaining was used in other industries including chemical, glass-making, medical and biomedical, and electrical. Platinum use in the autocatalyst sector decreased by 39% as a result of a decrease in light-duty vehicle production, which in turn was the result of the effects of the global economic downturn.

Global palladium sales were 212,000 kg in 2009, about 5% less than those in 2008. About 45% of the total was used by the autocatalyst industry, about 19% by the electronics industry, and about 12% by the jewelry industry. The remaining amount was used in industries such as chemical, dental, investment, and others.

In 2009, U.S. apparent consumption of refined platinum was estimated to be about 171,000 kg, a 24% increase from the apparent consumption of 138,000 kg in 2008. The increase was largely a result of investment buying. Apparent domestic palladium consumption was estimated to be about 52,000 kg, a 51% decrease from 106,000 kg in 2008.

Palladium.—Palladium use in autocatalysts decreased by 9% globally to 126,000 kg in 2009 compared with 2008 consumption. Demand in Europe fell only slightly despite a large decline in production of light-duty vehicles. A number of European Governments introduced automobile scrappage plans in order to encourage auto purchasing, and the scrappage plans resulted in the purchase of smaller, gasoline-powered vehicles. As a result, the market share of gasoline engines increased in Europe in 2009. Therefore, palladium consumption by the European diesel sector decreased slightly in 2009 relative to that of 2008, and automakers continued to increase substitution of palladium for platinum in diesel catalytic converters. Euro 5 emission standards were introduced in late 2009, and resulted in more vehicles being fitted with diesel particulate filters, which led to an increase in palladium and platinum use.

Consumption in the North American autocatalyst sector plummeted to 31,700 kg, a 21% decrease relative to that of 2008, owing to the global economic downturn and decline in vehicle purchases. In the United States, vehicle purchases dropped in 2009 compared with those in 2008, and only rose after the U.S. Government introduced the "Cash for Clunkers" auto scrappage plan in the middle of the year. The scrappage plan was a $3 billion program that provided economic incentives to purchase new, more fuel-efficient vehicles when trading in less fuel-efficient vehicles. The program resulted in sales of about 700,000 new vehicles. Palladium consumption in the Japanese autocatalyst industry was 18,400 kg, a 33% decrease compared with that of 2008. In contrast, palladium consumption in China increased to 21,300 kg, a 76% increase relative to that of 2008. Palladium consumption for autocatalysts in the rest of the world decreased by 15% to 23,600 kg relative to that of 2008 (Jollie, 2010, p. 36–40).

On a global basis, palladium consumption by the jewelry industry decreased to 25,300 kg, a 17% decrease in 2009 compared with that of 2008. The decrease was largely a result of the 24% drop in demand from China, to 17,400 kg of palladium. In China, jewelry manufacturers that had begun to produce palladium jewelry switched back to platinum as the platinum price declined. The level of demand in North America remained the same in 2009 as in 2008. China was again by far the leading user of palladium for jewelry, with 75% of world consumption in that sector. The much smaller markets in Europe and North America showed increases in palladium use in jewelry in 2009. Consumption in Europe was 1,560 kg of palladium, an 11% increase relative to that of 2008, and consumption in North America was 1,870 kg, the same as that in 2008. Consumption in Japan was 3,730 kg of palladium, a 4% increase relative to that of 2008 (Jollie, 2010, p. 39–40).

World palladium consumption in dental alloys was 19,100 kg in 2009, which was about 2% less than consumption in 2008. About 45% of the global consumption came from Japan and about 42% from North America. The chemical industry consumed 10,100 kg of palladium in 2009, a 7% decrease from that in 2008. The global decrease was the result of a slowdown in the construction of new plants owing to the global economic downturn. In the chemical industry, palladium is used mainly as a catalyst in manufacturing bulk chemicals, including purified hydrogen peroxide, nitric acid, purified terephthalic acid, and vinyl acetate monomer, a component of many resins and plastics. Consumption of palladium by the electronics industry was 39,500 kg in 2009, which was a 7% decrease compared with that of 2008. The leading use of palladium in the electronics industry was for multilayer ceramic capacitors (MLCCs), which are widespread in electronic circuitry. Trends toward miniaturization continued. Although the MLCCs became smaller, it was necessary to use a greater number of MLCCs per device. Thus, the amount of palladium per device remained about the same. Significant amounts of palladium also were used in hybrid integrated circuits, which are miniaturized electronic circuits constructed of individual devices, such as semiconductor devices and passive components, bonded to a substrate or printed circuit board. Use of palladium in other applications decreased by 7% in 2009 compared with that of 2008. Such uses included stationary-source emission control and petroleum refining catalysts. Purchases of palladium for investment increased to 19,400 kg, 49% higher than those of 2008. Holdings in ETFs were 20,060 kg at the beginning of 2009 and increased to 36,400 kg at yearend 2009, which was an increase of more than 300% compared with holdings at yearend 2008 (Jollie, 2010, p. 43).

Platinum.—Global use of platinum in the autocatalyst sector decreased by 39% to 69,400 kg in 2009 compared with that in 2008. Consumption in Europe was about 30,200 kg of platinum in 2009, about 51% less than that of 2008, and accounted for about 43% of the global total. The market share of light-duty diesel vehicles in Europe decreased to 46% in 2009 from 53% in 2008 as a result of auto scrappage plans by various European Governments, which had the effect of increasing sales of smaller gasoline-powered autos that use more palladium in their catalytic converters. Consumption in this sector for North America decreased by 27% in 2009 relative to that of 2008 owing to the drop in automobile purchases in response to the global financial downturn. Light-duty vehicle production fell sharply in North America in 2009. In Japan, platinum demand in the autocatalyst sector decreased by about 35%. Despite growth in vehicle production in China, demand for platinum in the autocatalyst sector decreased by 10% to 4,040 kg, owing to the replacement of platinum by palladium in catalysts. Consumption of platinum for autocatalysts decreased by 14% in other areas of the world despite increasingly stringent emission standards (Jollie, 2010, p. 24).

In 2009, global consumption of platinum in jewelry showed a sharp increase as a result of lower metal prices. Consumption in this sector was 93,600 kg of platinum, a 46% increase compared with that of 2008. Consumption in North America decreased by 33%, and consumption in Japan was about the same in 2009 relative to consumption in 2008. Consumption in China skyrocketed by 96% during the same time period. China remained, by far, the leading consumer in this sector at 64,700 kg, accounting for 69% of global consumption. In Europe, platinum consumption in the jewelry industry was 5,750 kg, a decrease of 10% compared with that in 2008 (Jollie, 2010, p. 28–30).

Global use of platinum in the chemical sector decreased to 9,180 kg in 2009, which was a drop of 26% compared with that of 2008. The decrease was partly the result of lower chemical production in response to the global economic downturn, which in turn resulted in platinum-based catalysts lasting longer. Purchases of platinum by the petroleum refining industry decreased by 15% to 6,380 kg in 2009, because of decreased consumer demand for refined petroleum products throughout the world. The global consumption of platinum in electrical applications decreased by 17%, to 5,900 kg in 2009, as compared with that of 2008, owing to weak consumer demand.

Because of its high melting point and resistance to corrosion, platinum equipment is used in the glassmaking industry. Platinum consumed in the glass industry plummeted to 311 kg in 2009, a 97% decrease compared with that of 2008. The drop was a result of several factors. A decrease in industrial demand for fiberglass caused a delay in the construction of fiberglass-producing factories. In addition, the lower rhodium price caused the fiberglass industry to move toward more durable, higher-rhodium, lower-platinum alloys, and platinum demand was therefore, lower. Also, there was weak demand in the first half of the year for flat-screen televisions, which use platinum in the production of liquid crystal displays. The weakened demand caused delay in plant construction for flat screens, but sales improved in the second half of the year, and glass manufacturers moved back into expansion mode. Consumption in the medical and biomedical sector was 7,780 kg, which was slightly higher than that in 2008. Consumption in other end uses decreased sharply to 5,900 kg, a 34% decrease relative to that of 2008. These categories included use in automotive sensors, coating of aircraft turbine blades, and spark plugs. Investment demand for platinum increased to 20,500 kg, a 19% increase relative to that of 2008. On a global basis, about 3,270 kg of platinum was purchased in the form of coins and small bars, and about 5,130 kg was purchased in the form of large bars. By yearend 2009, platinum holdings in ETFs increased 21,200 kg (Jollie, 2010, p. 25–33).

In 2009, the U.S. Mint did not sell any platinum American Eagle Bullion coins (U.S. Mint, 2010).

Other PGMs.—Global rhodium consumption in 2009 decreased to 22,300 kg, a 20% decrease compared with that of 2008. A majority of rhodium use, 82% in 2009, was in the production of autocatalysts. In 2009, rhodium use in autocatalysts decreased to 19,300 kg, which was 19% less than that of 2008. Demand for rhodium in the autocatalyst sector plummeted in Europe, Japan, and North America, as a result of declining vehicle production, a trend toward smaller vehicles, and rhodium thrifting. In contrast, rhodium demand in the autocatalyst sector in China increased to 3,640 kg, an increase of 52% compared with that of 2008. Use of rhodium in the glass manufacturing sector decreased sharply to 591 kg, a 44% drop in 2009 as compared with that in 2008. The drop was a result of reduced demand for fiberglass and flat-panel glass for liquid crystal displays. Rhodium was also released onto the market by some cathode-ray-tube glass factories that closed in China. On the other hand, the decrease in rhodium price in 2009 compared with that of the previous several years resulted in an increase of rhodium content of alloys used in the glass industry. Consumption of rhodium in the chemical sector decreased by 21% to 1,680 kg in 2009 owing to delays in construction of new oxoalcohol manufacturing plants in Asia. Demand from the electrical sector and other applications was down by 11% from that of 2008, at 746 kg (Jollie, 2010, p. 44).

Global consumption of ruthenium dropped for the third successive year. Demand decreased by 18% to 17,900 kg in 2009 relative to that in 2008. The consumption of ruthenium in electrical applications fell to 10,500 kg, an 18% decrease relative to that of 2008; consumption of primary ruthenium increased slightly in the hard disk industry. Electrochemical demand remained the same in 2009 as in 2008, at 2,960 kg of ruthenium, and its use in the chemical sector fell to 2,770 kg, a 36% decrease compared with that in 2008. Other demand for ruthenium decreased slightly to 1,680 kg in 2009.

Global consumption of iridium decreased to 2,830 kg in 2009, an 11% drop compared with 2008 consumption, reflecting a 53% decrease of iridium use in the electrical sector. Fewer iridium crucibles were manufactured for crystal-growing in 2009 than in previous years. Use of iridium in spark plugs in the aerospace and automotive industries decreased to 528 kg, a drop of 35% relative to levels in 2008 (Jollie, 2010, p. 45).

Prices

The 2009 Engelhard annual average price of palladium and platinum decreased by 25% and 23%, respectively, compared with the 2008 annual average prices. As for the other PGMs, the 2009 iridium annual price decreased by 6%, whereas rhodium and ruthenium annual prices plummeted by 76% and 70%, respectively, compared with the 2008 prices (table 1).

Iridium.—In the beginning of January, the price of iridium was $430 per troy ounce. The price dropped to $420 per troy ounce on January 16 and remained at that level throughout the rest of the year.

Palladium.—Palladium prices began the year at $186 per troy ounce, and for much of the year, the price trend was upwards in response to increased investor interest and a gradual improvement in automobile sales. The palladium price ended the year at $407 per troy ounce, more than double its level at the start of the year.

Platinum.—The platinum price began the year at $931 per troy ounce, and moved upward throughout most of the year, reaching $1,510 per troy ounce in early December and ending the year at $1,475 per troy ounce. The price increase was driven by a weaker U.S. dollar, a high gold price, a strong Chinese jewelry demand, and a return of investment demand and recovery in the automobile industry.

Rhodium.—The rhodium price began the year at $1,260 per troy ounce, rose steadily to $1,674 per troy ounce in mid-October, then skyrocketed to $2,790 in late November, before decreasing to $2,525 at yearend. The price rise was driven by physical and speculative interest as well as improvement in the auto industry by yearend.

Ruthenium.—The ruthenium price began the year at $100 per troy ounce and dipped to $75 per troy ounce in mid-February. The price climbed back to $95 per troy ounce in mid-April, where it remained until mid-November. The price jumped to $150 per troy ounce in late November and ended the year at $160 per troy ounce. The ruthenium price increased owing to industrial purchasing and investor interest.

Foreign Trade

In 2009, the U.S. net import reliance as a percentage of apparent consumption was estimated to be 89% for refined palladium and 97% for refined platinum. Imports of refined palladium in 2009 decreased by 42% to 69,700 kg from 120,000 kg in 2008, with three countries accounting for about 78% of refined palladium imports in 2009—Russia (33%), South Africa (29%), and the United Kingdom (16%). Imports of platinum, including waste, scrap, and coins, increased by 22% in 2009 to 183,000 kg, from 150,000 kg in 2008. Excluding waste and scrap, three countries accounted for 73% of imports of platinum in 2009—South Africa (43%), the United Kingdom (20%), and Germany (9%). Other refined PGM imports decreased by 53% in 2009 compared with those of 2008. Imports of iridium were down by 55%; those of rhodium and ruthenium were down by 33% and 56%, respectively, whereas imports of osmium were up by 196% compared with those of 2008. Three countries accounted for 90% of the imports of other PGM in 2009—South Africa (55%), Germany (24%), and the United Kingdom (11%) (tables 2, 3).

About 30,300 kg of palladium was exported in 2009, an increase of 15% relative to palladium exports in 2008 (table 4). Exports of platinum decreased by 33% to 47,100 kg, and exports of rhodium decreased by 39% compared with exports in 2008. Exports of iridium, osmium, and ruthenium dropped by 38% during the same time period.

World Review

In 2009, world mine production of PGMs decreased to 445,000 kg compared with 460,000 kg in 2008, which was a decrease of 3% (table 5). South Africa, the world's leading producer of PGMs, accounted for 61% of total mine production in 2009, Russia accounted for 26%, Canada accounted for 4%, and the United States and Zimbabwe each accounted for 3%. In 2009, platinum production from South Africa totaled 141,000 kg, which represented 78% of world platinum production and was a 4% drop relative to South African production in 2008. Global output of palladium dropped to 192,000 kg, with Russia and South Africa accounting for 43% and 39%, respectively, of the total. World production of other PGMs (iridium, osmium, ruthenium, and rhodium) in 2009 decreased slightly as compared with that of 2008. South Africa was the dominant producer, accounting for 78% of the total global production of other PGMs.

Australia.—Platinum Australia Ltd. (West Perth) completed significant work on updating the 2003 feasibility study at the Panton PGM Project in Western Australia. Completion of the feasibility study continued to be put on hold as a result of metal price drops (Platinum Australia Ltd., 2010, p. 15).

Botswana.—In 2009, Norilsk Nickel produced 3,110 kg of palladium and 529 kg platinum as byproducts from its nickel operations at the Tati Mine. These quantities represented a 5% increase in palladium production and an 11% decrease in platinum production compared with production in 2008 (OJSC MMC Norilsk Nickel, 2010, p. 55).

Canada.—North American Palladium Ltd. (Toronto, Ontario) had no production in 2009 because the Lac des Isles Mine had been placed on care-and-maintenance status in October 2008 in response to lower metal prices (North American Palladium Ltd., 2010).

Xstrata plc (Zug, Switzerland) continued to produce PGM as byproducts from nickel mining operations at Sudbury, although production figures were not released. Both output and headgrades improved at its Raglan nickel mine in northern Quebec (Jollie, 2010, p. 20). Vale Inco Ltd. (Toronto, Ontario) produced 4,730 kg of palladium and 3,200 kg of platinum as byproducts of its nickel operations at Sudbury. These data reflect production decreases for platinum and palladium of 38% and 34%, respectively, relative to production in 2008. Vale temporarily closed its Sudbury operations in June. In July, the workforce decided to go on strike, which prevented the operations from restarting (Jollie, 2010, p. 20).

Russia.—In 2009, Russia accounted for 43% of global mine production of palladium, 12% of other PGMs, and 12% of platinum production. Norilsk Nickel produced 83,200 kg of palladium, which was a slight decrease relative to 2008 production, and 19,800 kg of platinum, which was a slight increase compared with production in 2008 (OJSC MMC Norilsk Nickel, 2010, p. 55). Russia's alluvial production was 4,670 kg of platinum, which was a 14% decrease compared with 2008 production (Jollie, 2010, p. 19).

South Africa.—In 2009, South African production of platinum decreased by 4% compared with that of 2008 as a result of various problems, including closure of several uneconomic shafts and pits, geologic issues, labor unrest, safety-related mine closures, and smelter outages. The world's leading PGM producer, Anglo Platinum Ltd. (Johannesburg) produced 76,300 kg of platinum and 42,300 kg of palladium in 2009, increases of 3% for both platinum and palladium relative to production in 2008. Rhodium production was 10,900 kg in 2009, an increase of 17% relative to that of 2008. The global economic downturn led to shaft closures at Khuseleka and Siphumelele Mines (formerly part of the Rustenburg section), and output decreased there, but production increased at the Mogalakwena Mine owing to the commissioning of the Mogalakwena North expansion project in 2008. Anglo restructured its Amandelbult and Rustenburg Mines in response to low metal prices. Three Rustenburg shafts were closed, and expenditure on capital projects, such as the Amandelbult No. 4 shaft, was delayed. Production from the Mototolo Mine, a joint venture with Xstrata, increased to 3,400 kg, 25% higher than 2008 production. Production also increased at the Kroondal and Marikana Mines. At Modikwa, a joint venture with African Rainbow Minerals Ltd. (ARM), platinum production was 4,170 kg of platinum, which was a slight decrease relative to that of 2008. At the Bafokeng-Rasimone Platinum Mine (BRPM) joint venture, refined platinum production was 5,380 kg, a slight decrease relative to 2008 production. Anglo expected to produce 77,800 kg of platinum in 2010 (Anglo Platinum Ltd., 2010, p. 107–121).

Impala Platinum Holdings Ltd.'s (Johannesburg) refined production of platinum in 2009 was 27,000 kg, a 12% decrease compared with that of 2008. Production dropped as a result of several factors, including disruption in operations at the Rustenburg site caused by a workers' strike and a major rockfall in a mechanized section at 14 shaft that killed nine workers. Output at Marula increased slowly, as mining methods were switched from mechanized to conventional methods, and production for 2009 was 2,370 kg of platinum. The ramp up to full production at Two Rivers Mine was almost completed, and production included 4,110 kg of platinum in concentrate (Impala Platinum Holdings Ltd., 2010, p. 51–67).

In 2009, Northam Platinum Ltd. (Johannesburg) reported production from its Zondereinde Mine of 9,000 kg of PGMs in concentrate, an 8% increase compared with production in 2008 (Northam Platinum Ltd., 2010, p. 11).

Lonmin plc (London, United Kingdom) reported production for 2009 of 20,300 kg of platinum and 9,400 kg of palladium, a decrease of 9% and 10%, respectively, relative to 2008 production. Rhodium production fell to 2,820 kg, a 9% decrease relative to that of 2008. Ruthenium and iridium production were 4,290 kg and 927 kg, respectively, both of which were 9% less than production in 2008. Production fell because of safety shutdowns as well as operational changes that were made as a result of low metal prices. The Limpopo Mine was put on care-and-maintenance status, one uneconomic mine shaft and five half levels were closed at the Marikana Mine, and open pit mines were closed at the Marikana Mine and the Pandora Mine, a joint venture between Lonmin (42.5% interest), Anglo Platinum (42.5%), Mvelaphanda Resources Ltd. (Sandton) (7.5%), and Bapo Ba Mogale tribe (7.5%). Despite closure of the open pit, mining continued at Pandora by extracting ore through the adjacent shaft infrastructure at Marikana. Production at Pandora in 2009 was 1,240 kg of platinum, a decrease of 19% compared with that of 2008 (Lonmin plc, 2010, p. 2, 138).

Aquarius Platinum Ltd. (Bedford) suspended operations at the Everest Mine in December 2008 as a result of subsidence of the mined-out portion of the mine. No production took place in 2009, and the mine was in the process of being reestablished by yearend. Aquarius had two pool-and-share agreements with Anglo Platinum, at the Kroondal and Marikana Mines. Production from the Kroondal Mine, reported as metal in concentrate, included 7,490 kg of platinum, 3,750 kg of palladium, and 1,380 kg of rhodium. These values represented increases of 2%, 4%, and 5%, respectively, in the production of platinum, palladium, and rhodium relative to those of 2008. Production during 2009 from the Marikana Mine included 2,770 kg of platinum, 969 kg of palladium, and 460 kg of rhodium, which were increases of 7% and 12%, respectively, in the production of platinum and rhodium, and a decrease of 15% in palladium production relative to production in 2008. Production from the Chromite Tailings Retreatment Plant, a joint-venture project between Aquarius (50%), GB Mining and Exploration Ltd. (Johannesburg) (25%), and Sylvania South Africa Ltd. (West Perth) (25%), included 210 kg of palladium, 134 kg of platinum, and 61 kg of rhodium, a decrease of 11% for platinum production, and increases of 54% and 113% for palladium and rhodium, respectively, compared with that of 2008 (Aquarius Platinum Ltd., 2010, p. 17–19).

ARM platinum division had several joint ventures in South Africa—Modikwa Platinum Mine, 50% jointly owned with

Anglo Platinum; Nkomati Nickel Mine, 50% with Norilsk Nickel; and Two Rivers Platinum Mine, a project in which ARM held 55% and Implats 45%. Production from Modikwa was 4,170 kg of platinum, and from Nkomati, production was 1,300 kg of PGM, both reported on a 100% basis. Modikwa production was about the same as that of 2008, whereas Nkomati production decreased by 28%. Two Rivers produced 4,040 kg of PGM during 2009, which was an 18% increase relative to that of 2008 (African Rainbow Minerals Ltd., 2010, p. 31).

Eastern Platinum Ltd.'s (Vancouver, British Columbia, Canada) Crocodile River Mine produced 4,040 kg of PGMs in concentrate, a 10% increase from that in 2008 (Eastern Platinum Ltd., 2010, p. 60).

Platmin Ltd.'s (Centurion) Pilanesburg Mine produced 871 kg of PGM in concentrate during its first year of production. Full production of 7,770 kilograms per year (kg/yr) of PGMs was expected to be reached by 2011 (Platmin Ltd., 2010, p. 28).

Platinum Australia Ltd.'s Smokey Hills Mine began its first year of production in 2009 and produced about 840 kg of PGM in concentrate. Most of the ore came from an open pit, and Platinum Australia was in the process of ramping up underground production (Platinum Australia Ltd., 2010, p. 2).

Zimbabwe.—In 2009, production from Impala's Mimosa Mine was 2,850 kg of platinum, which was a 19% increase relative to production in 2008. Mimosa's Wedza phase 5.5 expansion was completed in May, and increased the PGM production capacity to 6,220 kg/yr. In 2009, production from Impala's Zimplats Mine was 5,490 kg of PGMs, slightly less than 2008 production. The phase I expansion project continued during the year, and portal 1 reached its full production capacity of 100,000 metric tons per month of ore in June. The Ngezi concentrator was commissioned in July and was expected to have a capacity of 5,600 kg/yr of platinum-in-matte (Impala Platinum Holdings, Ltd., 2010, p. 13, 64–73).

Anglo Platinum's Unki Mine, near Gweru, continued development in 2009, and the first ore was stockpiled and was expected to be processed in the last quarter of 2010 (Jollie, 2010, p. 21).

Outlook

The primary end use for palladium, platinum, and rhodium is for catalytic converters in the automotive industry; therefore, the outlook for that industry will have the greatest impact on the consumption and prices of these PGMs. The progress of the global economic recovery was expected to be the main driver of demand for PGMs. Although economic growth remains weak in most countries, consumer confidence is returning, and industrial output is increasing. Global automobile production is likely to increase in the near future; therefore, an overall increase in demand for PGM in that sector is expected. Manufacturers continued to switch to palladium-based catalytic converters. Thus, the increase in automobile demand will likely affect palladium demand in particular. Stricter emission standards in many areas of the world were expected to result in greater demand for PGMs in the automotive sector. In the electronics sector, palladium demand was likely to increase as the global economy recovers, because of increasing demand for consumer electronics in which palladium is used in MLCCs. In the glass sector, demand for platinum was expected to rise owing to an expected growth in the LCD and fiberglass industries. In the chemical sector, demand for platinum and palladium was expected to rise because of an increase in construction of manufacturing facilities. The demand for platinum in the jewelry sector was expected to drop worldwide because of the price rise. The consumption of rhodium was expected to increase as a result of higher vehicle demand in many areas of the world. Ruthenium demand was expected to increase as a result of increased demand from the hard disk industry. Iridium demand was likely to increase as a result of increased demand for use in spark plugs in the automobile sector. Iridium demand for crucibles used for the growth of metal oxide single crystals was also expected to increase.

On the supply side, platinum production from South Africa was expected to increase somewhat or remain level through 2010. However, production from South Africa will be dependent on several issues including timelines for new projects and ramp ups, stability of power supplies, availability and retention of skilled workers, quick resolution of labor disputes, and improved safety records. Supply from Zimbabwe could increase because of new mining projects, but this may be dependent on the political situation.

The proposed launch of two ETFs in the United States in 2010 was expected to result in increased demand for platinum and palladium in the investment sector. Because of volatile PGM pricing, investment in these funds is likely to continue to increase.

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TABLE 1
SALIENT PLATINUM-GROUP METALS STATISTICS[1]

		2005	2006	2007	2008	2009
United States:						
Mine production:						
Palladium, Pd content:[2]						
Quantity	kilograms	13,300	14,400	12,800	11,900	12,700
Value	thousands	$87,100	$150,000	$148,000	$136,000	$108,000
Platinum, Pt content:[2]						
Quantity	kilograms	3,920	4,290	3,860	3,580	3,830
Value	thousands	$113,000	$158,000	$162,000	$182,000	$149,000
Refinery production:						
Palladium, Pd content:						
Quantity	kilograms	5,220	5,660	7,410	7,650	7,840
Value	thousands	$34,100	$58,700	$85,100	$87,300	$66,900
Platinum, Pt content:						
Quantity	kilograms	6,360	6,870	8,930	7,400	7,220
Value	thousands	$184,000	$253,000	$375,000	$376,000	$280,000
Imports for consumption, refined:						
Iridium, Ir content	kilograms	3,010	2,800	3,410	2,550	1,520
Osmium, Os content	do.	39	56	23	11	68
Palladium, Pd content	do.	139,000	119,000	113,000	120,000	69,700
Platinum, includes waste, scrap, and coins, Pt content	do.	106,000	114,000	181,000	150,000	183,000
Rhodium, Rh content	do.	13,600	15,900	16,600	12,600	11,200
Ruthenium, Ru content	do.	23,200	36,000	48,700	49,800	21,200
Exports, refined:						
Iridium, osmium, and ruthenium, gross weight	do.	1,070 r	3,390	8,190	6,450	4,020
Palladium, Pd content	do.	27,000	53,100	41,800	26,400	30,300
Platinum, Pt content	do.	20,700	45,500	28,900	15,600	15,600
Rhodium, Rh content	do.	615	1,600	2,210	1,980	1,220
Stocks, National Defense Stockpile, December 31:						
Iridium, Ir content	do.	171 r	111	18	18	18
Palladium, Pd content	do.	--	--	--	--	--
Platinum, Pt content	do.	261	261	261	261	261
Price, average:						
Iridium[3]	dollars per troy ounce	169.51	349.45	444.43	448.34	420.40
Palladium[4]	do.	203.54	322.93	357.34	355.12	265.65
Platinum[4]	do.	899.51	1,144.42	1,308.44	1,578.26	1,207.55
Rhodium[4]	do.	2,059.73	4,561.06	6,203.09	6,533.57	1,591.32
Ruthenium[3]	do.	74.41	193.09	573.74	324.60	97.28
Employment		1,617 r	1,719	1,625	1,364	1,273
World, mine production e, PGM content	kilograms	504,000 r	514,000	507,000 r	460,000 r	445,000 e

e Estimated. r Revised. do. Ditto. -- Zero.

[1] Data are rounded to three significant digits, except prices.

[2] Source: Stillwater Mining Co., 2009 annual report, p. 46.

[3] Price data are annual averages of daily Engelhard unfabricated quotations published in Platts Metals Week.

[4] Price data are annual Engelhard unfabricated quotations published in Platts Metals Week.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF PLATINUM, BY COUNTRY[1]

Country	Grain and nuggets		Sponge		Other unwrought		Other		Waste and scrap		Coins	
	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)
2008	212	$7,210	45,700	$2,330,000	4,040	$177,000	7,180	$282,000	92,200	$593,000	734	$22,400
2009:												
Australia	--	--	--	--	(2)	4	280	12,300	61	2,310	5	112
Belgium	--	--	1,920	72,800	83	3,770	--	--	81	4,780	--	--
Bolivia	--	--	--	--	--	--	--	--	12,700	470	--	--
Brazil	--	--	231	8,140	--	--	6	246	925	7,960	--	--
Canada	12	293	1	12	1	15	231	7,980	7,730	22,000	477	19,300
Chile	--	--	--	--	--	--	--	--	9,940	17,400	--	--
China	--	--	--	--	--	--	7	412	1,500	6,450	1	22
Colombia	--	--	14	457	1,490	44,100	--	--	208	2,490	--	--
Germany	(2)	4	711	29,500	1,070	41,800	2,720	55,900	20,600	86,500	1	8
India	--	--	326	12,400	--	--	10	386	5	216	--	--
Italy	--	--	1,280	50,500	1	25	592	22,800	180	5,100	--	--
Japan	--	--	24	870	46	1,460	88	2,890	31,800	107,000	--	--
Mexico	--	--	48	1,770	46	1,460	13	274	15,400	18,900	--	--
Norway	--	--	1,470	59,400	--	--	--	--	--	--	--	--
Poland	--	--	--	--	--	--	--	--	17,400	766	--	--
Russia	1	61	1,610	59,200	115	4,240	--	--	--	--	--	--
South Africa	3	107	19,800	768,000	--	--	405	14,800	58	2,670	--	--
Switzerland	--	--	224	7,360	758	27,100	1,370	49,300	--	--	1	56
United Kingdom	--	--	9,450	351,000	40	1,090	168	5,880	214	5,560	27	1,060
Venezuela	--	--	--	--	--	--	4	87	12,300	373	--	--
Other	(2)	10	--	--	129	3,480	17	342	4,500	43,100	(2)	11
Total	16	474	37,100	1,420,000	3,770	129,000	5,910	174,000	136,000	334,000	512	20,500

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3

U.S. IMPORTS FOR CONSUMPTION OF PLATINUM-GROUP METALS, BY COUNTRY[1]

	Unwrought palladium		Palladium, other		Iridium[2]		Osmium[2]		Ruthenium[2]		Rhodium[2]	
Country	Quantity, Pd content (kilograms)	Value (thousands)	Quantity, Pd content (kilograms)	Value (thousands)	Quantity, Ir content (kilograms)	Value (thousands)	Quantity, Os content (kilograms)	Value (thousands)	Quantity, Ru content (kilograms)	Value (thousands)	Quantity, Rh content (kilograms)	Value (thousands)
2008	114,000	$1,270,000	6,810	$85,500	2,550	$36,600	11	$101	49,800	$426,000	12,600	$2,470,000
2009:												
Belgium	781	5,390	31	253	9	87	--	--	--	--	779	31,700
Canada	1,820	27,500	194	2,250	--	--	--	--	--	--	(3)	4
China	--	--	2	32	--	--	8	56	(3)	2	--	--
Germany	546	4,480	269	2,470	85	1,190	--	--	7,480	18,400	515	25,200
Italy	1,640	15,700	22	224	1	13	--	--	--	--	429	13,800
Japan	1,360	7,270	112	917	(3)	10	--	--	516	1,370	41	1,550
Norway	4,490	39,800	--	--	--	--	--	--	--	--	102	4,860
Russia	20,600	200,000	2,510	20,400	21	284	--	--	182	569	1,200	71,200
South Africa	19,500	166,000	804	5,960	1,040	13,600	60	495	10,100	26,500	7,540	353,000
Switzerland	871	7,740	3,080	26,600	--	--	--	--	--	--	--	--
United Kingdom	10,600	94,000	307	3,040	190	2,500	--	--	2,950	8,890	500	24,500
Other	97	613	18	222	175	3,110	--	--	--	--	77	4,010
Total	62,300	568,000	7,350	62,300	1,520	20,800	68	551	21,200	55,700	11,200	530,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Unwrought and other forms.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4

U.S. EXPORTS OF PLATINUM-GROUP METALS, BY COUNTRY[1]

Country	Palladium		Platinum		Platinum, waste and scrap		Iridium, osmium, ruthenium		Rhodium	
	Quantity, Pd content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, gross weight (kilograms)	Value (thousands)	Quantity, Rh content (kilograms)	Value (thousands)
2008	26,400	$197,000	15,600	$570,000	54,700	$1,190,000	6,450	$80,600	1,980	$302,000
2009:										
Australia	612	6,460	18	904	1	51	2	18	(2)	42
Austria	4	46	37	797	–	–	129	2,230	–	–
Belgium	117	815	236	9,770	105	3,820	–	–	2	196
Brazil	158	1,130	65	2,330	1	30	(2)	6	–	–
Canada	3,740	27,600	390	14,300	300	8,950	9	162	1	204
China	1,690	13,600	472	12,100	(2)	6	326	3,280	386	19,200
Czech Republic	470	802	(2)	3	–	–	–	–	–	–
France	298	2,250	58	1,330	1	10	8	49	–	–
Germany	2,470	22,800	4,010	124,000	6,400	46,600	1,850	9,620	136	4,460
Hong Kong	968	11,300	65	4,940	1	4	145	1,780	68	1,500
India	134	738	243	8,300	3	19	1	30	10	855
Ireland	59	253	135	4,350	–	–	13	82	(2)	6
Israel	2,010	5,620	46	734	–	–	–	–	–	–
Italy	3,780	38,800	1,200	50,600	5	264	13	196	47	2,090
Japan	3,030	24,900	3,310	118,000	683	19,200	231	2,500	250	11,500
Korea, Republic of	828	4,780	74	1,770	(2)	4	1	9	(2)	5
Mexico	605	1,180	91	3,320	–	–	105	2,990	1	108
Singapore	181	681	3	153	–	–	638	7,650	–	–
South Africa	62	174	3	144	4,350	17,700	1	12	7	810
Switzerland	4,050	27,400	3,810	123,000	624	7,390	56	480	31	2,060
Taiwan	1,550	7,630	65	1,940	3	10	416	2,520	5	453
Turkey	8	75	(2)	62	1	3	2	10	(2)	5
United Kingdom	2,350	20,500	781	22,100	18,700	417,000	49	605	271	4,500
Other	1,130	9,380	442	16,900	371	1,140	29	217	2	373
Total	30,300	229,000	15,600	522,000	31,600	523,000	4,020	34,400	1,220	48,400

– Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 5

PLATINUM-GROUP METALS: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1,2]

(Kilograms)

Country[3]	2005	2006	2007	2008	2009
Palladium:					
Australia[4]	550	750	600	700	600
Botswana	1,900	2,000	5,000	3,000	3,000
Canada	10,415[5]	10,493[5]	10,900[r]	10,000[r]	6,500
Japan[6]	5,400	5,400	5,500	5,500	5,600
Poland[7,8]	10	10	15[r]	15[r]	15
Russia	97,400	98,400	96,800	87,700	83,200[5]
Serbia	19[9]	15	15	15	15
South Africa	82,961[5]	86,265[5]	83,643[5]	75,537[r,5]	75,118[5]
United States[10]	13,300[5]	14,400[5]	12,800[5]	11,900[r,5]	12,700[5]
Zimbabwe	3,879[5]	4,022[5]	4,180[5]	4,386[5]	5,680
Total	216,000	222,000	219,000[r]	199,000[r]	192,000
Platinum:					
Australia[4]	111	209	142	200	200
Botswana	300	300	700	600	600
Canada	6,075[r,5]	7,500	7,000	7,000	4,600
Colombia	1,082[5]	1,438[5]	1,526[5]	1,500	1,500
Ethiopia[11]	--	4[r]	5[r,5]	10[5]	10
Finland	800	800	800	800	800
Japan[6]	760	760	770	770	780
Poland[7,8]	20	20	25[r]	25[r]	25
Russia	29,000	29,000	27,000	23,000	21,000
Serbia	3[9]	2	2	2	2
South Africa	163,711[5]	168,125[5]	160,940[5]	146,140[5]	140,819[5]
United States[10]	3,920[5]	4,290[5]	3,860[5]	3,580[r,5]	3,830[5]
Zimbabwe	4,834[5]	4,998[5]	5,306[5]	5,642[5]	7,230
Total	211,000[r]	217,000	208,000	189,000	181,000
Other platinum-group metals:					
Canada	5,000	5,000	4,000	4,000	2,600
Russia	15,500	15,600	14,500	12,500	11,900
South Africa	56,309[5]	53,138[5]	59,449[5]	53,999[r,5]	55,454[5]
Zimbabwe	862[5]	864[5]	1,695[5]	1,804[5]	800
Total	77,700	74,600	79,600	72,300[r]	70,800
Grand total	504,000[r]	514,000	507,000[r]	460,000[r]	445,000

[r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 7, 2010. Platinum-group metal (PGM) production by Germany, Norway, and the United Kingdom is not included in this table because the production is derived wholly from imported metallurgical products and to include it would result in double counting.

[3] In addition to the countries listed, China, Indonesia, and the Philippines are thought to produce PGM, and several other countries may also do so, but output is not reported quantitatively, and there is no reliable basis for the formulation of estimates of output levels. A part of this output not specifically reported by country is, however, presumably included in this table credited to Japan.

[4] PGM recovered from nickel ore that is processed domestically. PGM in exported nickel ore are extracted in the importing countries, such as Japan, and are thought to be included in the production figures for those countries.

[5] Reported figure.

[6] Production derived entirely from imported ores.

[7] Based on official Polish estimates.

[8] Estimates based on reported platinum- and palladium-bearing final (residual) slimes and then average Pt and Pd content from electrolytic copper refining.

[9] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[10] A very small quantity of byproduct platinum and palladium produced from gold-copper ores was excluded.

[11] Data for the Ethiopian calendar year ending July 7 of that stated. Yubdo Mine only. Platinum was also reportedly contained in gold ingots from the Lega Dembi Mine, but information is inadequate to estimate output.

POTASH

By Stephen M. Jasinski

Domestic survey data and tables were prepared by Linda M. White, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2009, the world potash market collapsed owing to the global economic downturn and a drop in demand. High potash prices in the first half of 2009 contributed to the drop in consumption as farmers delayed purchases until prices fell. This led to high inventories and the temporary closure of many potash mines. World production was less than 50% of rated capacity in 2009; its lowest level since 1993. In the United States, about 1.7 million metric tons (Mt) of minerals was mined to produce 720,000 metric tons (t) of potassium oxide (K_2O) equivalent. U.S. production was at its lowest point since 1943. U.S. potash production was 35% less in 2009 than in 2008, and the total value of sales decreased by 32% from that of 2008. The unit value for potash increased from $300 per metric ton in 2008 to $335 per ton in 2009, although this was because of high prices in the first half of the year, which had decreased substantially by yearend. Apparent consumption of potash decreased by 62% from that of 2008, to reach its lowest point since 1962. Imports of potash decreased 62% from those of 2008, while exports increased by 36% (table 1).

Potash denotes a variety of mined and manufactured salts, all of which contain the element potassium in water-soluble form. The majority of domestic potash was produced near Carlsbad, NM, with most of the potash coming from the mineral sylvite. The term potash refers to potassic fertilizers, which are potassium chloride (KCl or sylvite), potassium sulfate [K_2SO_4 or sulfate of potash (SOP), usually a manufactured product], and potassium-magnesium sulfate [$K_2SO_4 \cdot 2MgSO_4$ or langbeinite or double sulfate of potash magnesia (SOPM or K-Mag)]. Muriate of potash (MOP) is an agriculturally acceptable mix of KCl (95% pure or greater) and sodium chloride (halite) for fertilizer use that includes minor amounts of other nontoxic minerals from the mined ore and is neither the crude ore sylvinite nor pure sylvite.

This publication has historically included potassium nitrate [KNO_3 or saltpeter or nitrate of potash (NOP), a mostly manufactured product] and mixed sodium nitrate and potassium nitrate ($NaNO_3$ and KNO_3 or Chilean saltpeter, a natural product) because these materials function as potassic plus nitrogenous fertilizers. Saltpeter and Chilean saltpeter are still included in the import tables (tables 5, 6).

Production

Domestic production data were developed by the U.S. Geological Survey (USGS) from a semiannual voluntary canvass of U.S. operations. All of the seven operations canvassed for semiannual production data responded to the surveys.

Three companies produced potash from seven operations in three States. Most domestic production was from southeastern New Mexico, where Intrepid Potash, Inc. operated two mines and The Mosaic Company operated one mine. Mosaic also operated a deep-solution mine in Michigan. The third State with potash production was Utah, where Intrepid produced potash from a solution mine in Moab and from a solar evaporation facility in Wendover, and Great Salt Lake Minerals Corp. (a subsidiary of Compass Minerals International, Inc.) operated a solar evaporation facility in Ogden.

Potash companies in the United States produced MOP, SOP, and SOPM. Published production data of all types and grades of potash in the United States are adjusted to avoid disclosing the proprietary data of companies that produce SOP and SOPM, which together are known as sulfates.

Intrepid continued with its plans to reopen the underground HB Mine, which is located near the company's existing mines in Carlsbad, NM, as a solution potash mine. The HB Mine was closed in 1996 by the previous owner. The facility would increase annual production by 200,000 metric tons of MOP. Intrepid expects the mine to be fully permitted by mid-2011, and production could start about 1 year after that (Intrepid Potash, Inc., 2010, p. 5).

In 2009, domestic consumption of K_2O equivalent was 62% lower compared with that of 2008, owing to the economic recession, high potash prices in the first half of the year, and the subsequent drop in demand. The principal use of potash is as an agricultural fertilizer (plant nutrient) because it is a source of soluble potassium, which is one of the three primary plant nutrients required for plant growth and maturation; the others are fixed nitrogen and soluble phosphorus. Potash and phosphorus are mined products, and fixed nitrogen is produced from the atmosphere using industrial processes. Modern agricultural practice uses large amounts of these primary nutrients and additional nutrients, such as boron, calcium, chlorine, copper, iron, magnesium, manganese, molybdenum, sulfur, and zinc, to ensure plant health and proper maturation. The three major plant nutrients have no cost-effective substitutes. Low-nutrient-content alternative potash sources, such as animal manure and guano, bone meal, compost, glauconite, and "tankage" from slaughterhouses, are available, but the cost of transportation per metric ton of nutrient beyond relatively short distances can reduce their desirability. In addition to its use as a fertilizer, potassium chloride is important in industrialized economies, where it is used in aluminum recycling, by the chloralkali industry to produce potassium hydroxide, in metal electroplating, oil-well drilling mud, snow and ice melting, steel heat-treating, and water softening.

Potassium hydroxide is used for industrial water treatment and is the precursor of potassium carbonate, several forms of potassium phosphate, many other potassic chemicals, and soap manufacturing. Potassium carbonate is used to produce animal feed supplements, cement, fire extinguishers, food products, photographic chemicals, and textiles. It is also used in brewing beer, pharmaceutical preparations, and as a catalyst for synthetic rubber manufacturing. Generally, these nonfertilizer uses have accounted for about 15% of annual potash consumption in the United States.

Foreign Trade

U.S. exports of potash (gross weight) increased slightly in 2009 from those of 2008, owing to increased sales of MOP. Exports of 705,000 t were reported, of which 49% was MOP, 44% was SOPM, 6% was SOP, and 1% was NOP (table 3). Brazil, Mexico, and Canada in declining order, received 54% of the total exports of potash from the United States (table 4). Total potash exports, reported by K_2O content, increased by 36% in 2009 compared with those of 2008.

Potash imports (gross weight) into the United States for 2009 decreased by 62% to 3.67 Mt compared with 9.56 Mt in 2008 (table 5). The leading source of all potash imports was Canada with 88% of the total (table 6).

World Industry Structure

Estimated 2009 world potash production decreased by 40% to 20.8 Mt, with decreased output from all major producing countries, except for China (table 7). The collapse of global trade in response to reduced world demand and the global economic downturn resulted in high producers' stocks and temporary mine closures. Only 13 countries are notable potash producers, with Belarus, Canada, China, Germany, Israel, Jordan, and Russia accounting for about 90% of global production capacity. World potash production in 2009 was at 48% of rated annual capacity (Heffer and Prud'homme, 2010).

World Review

Argentina.—Companhia Vale de Rio Doce (Vale) of Brazil purchased the Rio Colorado potash project from Rio Tinto Plc in early 2009. Vale planned to develop a 4.3-million-metric-ton-per year (Mt/yr) MOP solution mine in Malargue in Mendoza Province beginning in 2011 for completion by 2017 and a solution mine in Neuquen Province in the longer term (Green Markets, 2009).

Canada.—The effects of the world economic downturn and the global drop in potash demand were the main factors in a 60% decrease in Canadian potash production in 2009 compared with 2008. All three major producers— Agrium, Inc., Mosaic, and Potash Corp. of Saskatchewan (PotashCorp)—drastically reduced output in 2009. Despite the economic conditions, potash expansion and exploration projects by major producers and other companies continued during the year, although completion of most of the projects was delayed.

In Saskatchewan, PotashCorp planned to expand and debottleneck its Allan and Cory plants and replace existing mines and expand processing plants in Rocanville, as well at its operation in Sussex, New Brunswick. The projects would increase the company's annual production capacity to 17.1 Mt MOP sometime in 2015 (Stone, 2010).

Mosaic planned to add 300,000 t of annual capacity at its Colonsay and Esterhazy Mines in Saskatchewan by the end of 2011. Agrium planned to expand its potash production capacity at its Vanscoy Mine by 40% by the end of 2015 (Stone, 2010).

Vale acquired the Rio Tinto Regina potash deposit in Saskatchewan in early 2009. Vale planned to develop a 2.8-Mt/yr MOP solution mine sometime after 2015 (Green Markets, 2009).

Outlook

In late 2008, the effects of the global economic recession, combined with high potash prices and weak demand, led to a collapse in the world potash market. The weak market conditions that followed the collapse of the potash market continued throughout 2009. Producers' stocks remained high, and many buyers waited for prices to fall before reentering the market. Early in 2009, most leading world producers announced indefinite reductions in production, which amounted to about one-half of world production capacity. The leading consuming countries, including Brazil, China, India, and the United States, were all projected to have major decreases in consumption in 2010.

Beginning in 2010, world potash production was expected to rebound to close to that of 2008, as producer stocks decreased gradually as consumption recovered. Potash applications will be needed to replenish soil nutrient levels in most regions after the drop in consumption in 2009. According to the International Fertilizer Industry Association (IFA), world potash production was forecast to increase from 20.8 Mt in 2009 to 31.1 Mt in 2010, and consumption was forecast to increase from 24.9 Mt in 2009 to 30.0 Mt in 2010 (Heffer and Prud'homme, 2010). Potash capacity expansion plans remained on schedule, with the expected completion of projects in Canada, Chile, Jordan, and Uzbekistan in 2011 and in Argentina, Belarus, Brazil, Laos, and Russia by 2015.

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TABLE 1

SALIENT POTASH STATISTICS[1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

		2005	2006	2007	2008	2009
United States:						
Production:[3]						
Gross weight		2,500	2,400	2,600	2,500	1,700
K_2O equivalent		1,200	1,100	1,100	1,100	720
Sales by producers:						
Quantity:[3]						
Gross weight		2,500	2,400	2,600	2,400	1,500
K_2O equivalent		1,200	1,100	1,200	1,100	630
Value[3, 4]		410,000	410,000	480,000	740,000	500,000
Average value:[5]						
Gross weight	dollars per metric ton	$165	$170	$185	$300	$330
K_2O equivalent	do.	$350	$375	$400	$670	$800
Exports:						
Gross weight		569	809	510	694	705
K_2O equivalent		200	332	199	222	303
Imports for consumption:[6, 7]						
Quantity:						
Gross weight		8,110	7,380	8,190	9,560	3,670
K_2O equivalent		4,920	4,470	4,970	5,800	2,220
Value, customs		1,170,000	1,150,000	1,310,000	3,260,000	2,210,000
Consumption, apparent:[3, 8]						
Gross weight		10,000	9,000	10,000	11,000	4,500
K_2O equivalent		5,900	5,200	5,900	6,700	2,500
World, production, marketable K_2O equivalent		33,800	30,400 [r]	35,700 [r]	34,500 [r]	20,800

[r] Revised. do. Ditto.

[1] Includes muriate of potash, sulfate of potash, potassium magnesium sulfate, and some parent salts. Excludes other chemical compounds that contain potassium.

[2] Data are rounded to no more than three significant digits unless otherwise specified.

[3] Data are rounded to no more than two significant digits.

[4] Free on board mine.

[5] Rounded to the nearest $5 to avoid disclosing proprietary data.

[6] Excludes potassium chemicals and mixed fertilizers.

[7] Includes nitrate of potash.

[8] Calculated from sales plus imports minus exports.

TABLE 2

PRICES OF U.S. POTASH, BY TYPE AND GRADE[1, 2]

(Dollars per metric ton of K_2O equivalent)

	2008			2009		
Type and grade	January–June	July–December	Yearly average	January–June	July–December	Yearly average
Muriate, 60% K_2O minimum:						
Standard	445	865	640	1,300	650	870
Granular	440	620	470	775	545	620

[1] Average prices, free on board mine, based on sales.

[2] Data rounded to nearest $5.

TABLE 3

U.S. EXPORTS OF POTASH, BY TYPE[1]

	Approximate average K_2O equivalent content (percentage)	Quantity (metric tons)	
		Gross weight	K_2O equivalent[e]
2008:			
Potassium chloride, all grades	61	104,000	63,400
Potassium sulfate	51	94,800	48,300
Potassium magnesium sulfate	22	490,000	108,000
Potassium nitrate	45	5,090	2,290
Total	XX	694,000	222,000
2009:			
Potassium chloride, all grades	61	342,000	208,000
Potassium sulfate	51	42,400	21,600
Potassium magnesium sulfate	22	313,000	68,800
Potassium nitrate	45	8,450	3,800
Total	XX	705,000	303,000

[e] Estimated. XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 4
U.S. EXPORTS OF POTASH, BY COUNTRY[1]

(Metric tons of product)

Country	Potassium chloride		Potassium sulfates, all grades[2]		Potassium nitrate		Total	
	2008	2009	2008	2009	2008	2009	2008	2009
Angola	4,730	123	--	--	--	--	4,730	123
Australia	3	--	30,000	8	65	534	30,100	542
Barbados	98	107	7	--	10	39	115	146
Brazil	13,000	225,000	9,520	15,000	--	--	22,500	240,000
Canada	6,110	5,520	76,000	51,800	943	1,350	83,100	58,700
Chile	--	4,630	62,600	37,000	--	--	62,600	41,700
China	6	3	36,400	379	52	2	36,400	384
Colombia	46	12,200	37,700	32,900	25	--	37,700	45,000
Costa Rica	--	19,700	39,700	27,300	1	1	39,700	47,000
Cote D'Ivoire	--	--	5,470	--	--	--	5,470	--
Czech Republic	10	--	--	--	--	--	10	--
Dominican Republic	--	4,230	5,800	1,880	--	--	5,800	6,100
Ecuador	435	4,140	8,640	8,600	--	--	9,070	12,700
El Salvador	--	3,860	6,300	1	13	--	6,310	3,860
Equatorial Guinea	105	19	--	--	--	--	105	19
Gabon	1,460	--	--	--	--	--	1,460	--
Germany	138	72	2	11	1	2	141	85
Ghana	--	3,130	14,400	8,190	--	--	14,400	11,300
Guadeloupe	--	1,200	--	715	--	--	--	1,910
Guatemala	12	6,100	7,800	3,770	--	--	7,810	9,870
Honduras	--	3,930	7,700	11,300	--	6	7,700	15,300
India	--	8	16,700	19,700	--	1	16,700	19,700
Indonesia	12	--	667	143	--	--	679	143
Japan	6,660	591	64,400	44,100	--	--	71,000	44,700
Korea, Republic of	2,010	102	30	6,460	45	79	2,080	6,640
Martinique	8,810	1,000	2,910	825	--	--	11,700	1,830
Mexico	53,000	36,400	79,500	40,300	2,750	2,550	135,000	79,200
Netherlands	478	39	19	--	366	3,200	863	3,230
New Zealand	--	--	9,950	7,050	28	--	9,970	7,050
Nicaragua	36	--	4,500	2,070	--	--	4,540	2,070
Nigeria	5,510	--	--	--	--	--	5,510	--
Peru	66	7,200	18,100	6,010	--	--	18,200	13,200
Russia	206	--	--	--	--	--	206	--
Switzerland	188	250	--	--	--	--	188	250
Thailand	200	140	2,530	--	12	204	2,740	344
Trinidad and Tobago	590	1,840	--	32	--	--	590	1,870
United Kingdom	8	11	40	5,420	--	--	48	5,430
Venezuela	--	--	37,200	23,600	--	--	37,200	23,600
Other	130 r	170	474 r	376	781	492	1,390 r	1,040
Total	104,000	342,000	585,000	355,000	5,090	8,450	694,000	705,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes potassium magnesium sulfate.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 5

U.S. IMPORTS FOR CONSUMPTION OF POTASH, BY TYPE[1]

	Approximate average K_2O equivalent content (percentage)	Quantity (metric tons)		Value (thousands)	
		Gross weight	K_2O equivalent[e]	Customs	C.i.f.[2]
2008:					
Potassium chloride[3]	61	9,350,000	5,700,000	$2,950,000	$3,020,000
Potassium sulfate	51	73,800	37,600	56,600	59,900
Potassium nitrate	45	133,000	59,700	75,800	80,200
Potassium sodium nitrate mixture	14	234	33	189	191
Total	XX	9,560,000	5,800,000	3,080,000	3,160,000
2009:					
Potassium chloride[3]	61	3,510,000	2,140,000	1,610,000	1,630,000
Potassium sulfate	51	87,600	44,700	63,700	65,900
Potassium nitrate	45	74,100	33,300	106,000	107,000
Potassium sodium nitrate mixture	14	658	92	265	274
Total	XX	3,670,000	2,220,000	1,780,000	1,810,000

[e] Estimated. XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight.

[3] Contains imports listed under Harmonized Tariff Schedule of the United States code 3104.10.0000.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF POTASH, BY COUNTRY[1]

	Potassium chloride (metric tons)		Potassium sulfate (metric tons)		Potassium nitrate (metric tons)		Potassium sodium nitrate (metric tons)		Total					
									Quantity (metric tons)		Value (thousands)			
											Customs		C.i.f.[2]	
Country	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Australia	227	--	--	--	--	--	--	--	227	--	$22	--	$23	--
Belarus	145,000	--	--	--	--	--	--	--	145,000	--	60,600	--	64,100	--
Belgium	13	2	59	5,200	--	10	--	--	72	5,210	105	$3,910	115	$4,110
Canada	8,130,000	3,220,000	20,400	21,000	--	--	233	199	8,150,000	3,240,000	2,140,000	1,490,000	2,150,000	1,500,000
Chile	1,740	11,200	293	5,630	86,200	64,400	--	--	88,200	81,200	62,500	114,000	65,600	115,000
China	2	48,800	16	6	61	399	1	1	80	49,200	95	23,400	104	24,500
Denmark	--	--	--	--	397	--	--	--	397	--	117	--	127	--
France	--	--	1,620	1,650	22	43	--	--	1,640	1,690	273	347	320	376
Germany	5,500	23,300	51,200	54,100	3,180	5,260	--	432	59,900	83,100	47,600	44,800	50,600	46,500
India	100	50	28	2	159	32	--	--	287	84	156	78	183	85
Ireland	--	--	--	--	139	7	--	--	139	7	49	9	57	10
Israel	19,200	9,210	--	--	32,900	1,820	--	--	52,100	11,000	13,300	1,700	16,000	1,960
Italy	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Japan	--	--	99	48	1,790	1,900	--	--	1,890	1,940	631	630	704	662
Jordan	291	--	--	--	7,370	61	--	--	7,660	61	2,200	28	2,490	28
Lativa	64,500	--	--	--	--	--	--	--	64,500	--	49,400	--	50,800	--
Mexico	500	--	--	1	14	107	--	--	514	108	488	46	500	48
Netherlands	--	--	--	--	--	--	--	5	--	--	--	5	--	7
Poland	--	--	--	--	346	--	--	--	346	--	102	--	110	--
Russia	970,000	194,000	--	--	--	--	--	--	970,000	194,000	702,000	104,000	745,000	110,000
Singapore	--	--	--	--	1	--	--	--	1	--	3	--	3	--
Switzerland	13	4	--	--	--	1	--	--	13	5	10	11	11	11
United Kingdom	1,870	2,270	--	--	1	42	--	21	1,870	2,340	118	239	118	245
Venezuela	11,600	--	--	--	--	--	--	--	11,600	--	5,780	--	6,280	--
Other	--	--	--	56	--	1	--	--	--	62	--	100	--	108
Total	9,350,000	3,510,000	73,800	87,600	133,000	74,100	234	658	9,560,000	3,670,000	3,080,000	1,780,000	3,160,000	1,810,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 7

MARKETABLE POTASH: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons of K_2O equivalent)

Country	2005	2006	2007	2008	2009
Belarus	4,844	4,605	4,972	4,968	2,485
Brazil	405	403	424 [r]	383 [r]	385 [p]
Canada	10,140	8,518	11,085	10,455	4,318
Chile	547 [r]	496 [e]	515	559	692
China[e]	1,500	1,800	2,600	2,750	3,000 [e]
Germany	3,664	3,625	3,637	3,280	1,800
Israel	2,224	2,187	2,182	2,170 [r]	2,100 [e]
Jordan	1,115	1,036	1,096	1,223	683
Russia[3]	7,131	3,720	7,275	6,730	3,727
Spain[e]	575	435 [3]	435	435	435 [e]
Ukraine	13	8	12	12 [r, e]	12 [e]
United Kingdom	439	420	427	427 [e]	427 [e]
United States[4]	1,200	1,100	1,100	1,100	700
Total	33,800	30,400 [r]	35,700 [r]	34,500 [r]	20,800

[e] Estimated. [p] Preliminary. [r] Revised.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through October 15, 2010.

[3] Reported figure.

[4] Rounded to no more than two significant digits.

PUMICE AND PUMICITE

By Robert D. Crangle, Jr.

Domestic survey data and tables were prepared by Paula R. Neely, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2009, U.S. pumice and pumicite production was 410,000 metric tons (t). This was a decrease of 48% compared with that of 2008, when the United States produced 791,000 t. The overall value of pumice production in 2009 was $12.3 million, a decrease of 23% from that in 2008. The observed decreases in total production and value came as a result of the stagnant U.S. housing and construction industries, where pumice is used in building blocks, concrete, and landscaping. The apparent consumption of pumice and pumicite in the United States in 2009 was 425,000 t, a decrease of 50% compared with that of 2008. Imports decreased by 60% to 26,000 t. Exports of 11,000 t represented a decrease of approximately 27% compared with 15,000 t of exported pumice and pumicite in 2008 (table 1). Pumice imports and exports represent relatively small amounts of U.S. apparent consumption and are subject to large annual fluctuations in terms of percentage.

Pumice is an extrusive igneous volcanic rock formed through the cooling of air-pocketed lava, which results in a highly porous, low-density rock (Presley, 2006). The low density allows some pumice to float on water. Large pumice rafts, a unique geologic phenomenon, have been documented to be as long as 30 kilometers (km) and to drift for several years in oceanic waters (Wood-Jones, 1910, p. 290–291; Bryan and others, 2004, p. 136). Pumicite is defined as grains, flakes, threads, and (or) shards of volcanic glass finer than 0.10 inch [4 millimeters (mm)] in diameter (Harben and Bates, 1984, p. 64). Pumicite and volcanic ash are descriptive terms that are often interchangeably used.

The porous, lightweight properties of pumice are well suited for its main use as an aggregate in lightweight building blocks and assorted building products. In 2009, other major applications included abrasives, horticulture (including landscaping), and stonewashing of denim. Minor applications incorporated the use of pumice as an absorbent, as a concrete aggregate and admixture, as a filter aid, and as a traction enhancer for tires. A small percentage of pumice was used in abrasive-type products, including pencil erasers, a polishing agent for circuit boards and television monitors, an exfoliant in cosmetics, and a variety of heavy-duty hand cleaners. Imports were primarily used as raw material for blocks and as a lightweight aggregate.

Production

Domestic production data for pumice and pumicite were developed by the U.S. Geological Survey (USGS) from an annual voluntary review of U.S. pumice- and pumicite-producing sites and company operations. The canvass for 2009 included 15 companies with 17 active operations that produced, used, or sold pumice and pumicite in the United States. All 15 companies responded, accounting for 100% of the 410,000 t produced in 2009. Data were rounded to no more than three significant digits. All percentages in this report were computed based on unrounded data.

U.S. pumice and pumicite production of 410,000 t was valued at $12.3 million. Pumice and pumicite were produced in seven States in 2009, with 26% of production from California, followed by Oregon with 24%, and New Mexico with 21%. Other States that produced pumice, in order of decreasing production, were Idaho, Nevada, Arizona, and Kansas.

Pumice is usually extracted by simple open pit methods using rippers, bulldozers, and front-end loaders. Processing is typically limited to drying, crushing, and screening, although some abrasive grades may require fine grinding and classification. Pumice blocks may be sawn into a variety of shapes and sizes.

Consumption

In 2009, more than 239,000 t, or 58% of the pumice and pumicite produced in the United States, was used for building and decorative blocks (table 2). This was a 62% decrease from that of 2008. Pumice used for horticultural and landscaping purposes in 2009 increased by 120% to 101,000 t from the 2008 reported total of 46,000 t. Horticultural and landscaping applications accounted for 25% of total consumption in 2009. Pumice and pumicite for concrete admixture and aggregate decreased by 32% to 28,000 t in 2009 from 41,000 t in 2008 and accounted for 7% of consumption. Pumice used as an abrasive in 2009 decreased by 64% to a total of 8,000 t, which accounted for 2% of consumption. The amount of pumice reported sold or used by several low-volume markets or for unreported uses grouped in the "other" category decreased by 45% to 34,000 t in 2009 from 62,000 t in 2008 and accounted for 8% of consumption. "Other" uses nominally included absorbent (including pet litter), cosmetics, diluents, engineered fill, filter aids, geotechnical aids, pottery clays, highway snow control, and other unspecified uses. There are several substitutes for pumice in agriculture, horticulture, as an aggregate, as a concrete additive, and other end products.

Prices

As a result of a small pumice-producing community, coupled with producer-specific end-use products, the average prices reported for pumice and pumicite in 2009 varied greatly by use compared with the average price for all uses in 2008. The overall average prices reported for all pumice and pumicite products increased by 49% to $29.97 per metric ton in 2009 from $20.13 per ton in 2008. The price change reflected the increases in unit values of specialty abrasive products, building block, and concrete admixture and aggregate. Decreases in the unit values of pumice were seen in nonspecialty abrasives and in horticulture and landscaping. The unit value of the building block and decorative use category increased by 80% to $23.13 per ton in 2009 from $12.86 per ton in 2008. This large increase was the result of a significant production drop, coupled with higher prices from the fewer producers that continued to manufacture products in this category. The average price for pumice and pumicite used for horticultural and landscaping decreased by 24% to $29.57 per ton in 2009 from $38.89 per ton in 2008. The average price in 2009 for pumice and pumicite used in nonspecialty abrasive applications was $9.38 per ton, a drop of 85% from the reported amount of $60.95 per ton in 2008. This significant decrease was caused by a single company's production cessation of this product. For concrete admixture and aggregates, $29.93 per ton was reported for 2009, an increase of 11% from the 2008 value of $26.90 per ton. For other uses, the 2009 unit value of $84.97 per ton was 42% more than the $60.06 unit value reported in 2008 (table 2).

Foreign Trade

Export and import data presented here, which are from the U.S. Census Bureau, are of limited accuracy. This is a result of inconsistencies in producer reporting, coupled with a lack of detail for materials specified in the 2009 Harmonized Tariff Schedule of the United States (HTS), as issued by the U.S. International Trade Commission. The trade data were published under subheading 2513.10 of the HTS, described as applying to pumice stone. Industry sources, however, indicated that pumice may be included under the general heading 2513, which included corundum garnets and other natural abrasives.

Exports of pumice, mostly specialty products, decreased to approximately 11,000 t, with a value of $5.1 million in 2009, or about $465 per ton. This was a 27% decrease in tonnage from the 15,000 t valued at $7.2 million in 2008. Canada accounted for 30% of 2009 exports, followed by Hong Kong with 13%, China with 12%, the United Kingdom with 9%, Italy with 8%, and the United Arab Emirates with 5%. Small amounts of pumice and pumice products were exported to 57 other countries.

Imports of crude or unmanufactured pumice and pumicite in 2009 decreased by 60% to 26,000 t compared with 65,000 t reported in 2008. By volume, most imports of pumice and pumicite were raw materials for blocks and lightweight aggregate in construction-related uses, with smaller amounts used in a range of abrasives and for stonewashing denim. Eighty-one percent of imported crude pumice came from Greece (table 3), which supplied 21,000 t of crude pumice to the United States in 2009 and remained the leading source of pumice imports. Pumice from Montserrat totaled 3,600 t, or 14% of total imported pumice, in 2009. Twelve other countries supplied small amounts of pumice and pumicite in 2009. Italy, which had been a major source of pumice into the United States until 2007, provided small amounts in 2009 owing to the continued closure of the mining facilities of Pumex S.p.A. on the island of Lipari.

World Review

Pumice is used more extensively as a building material outside the United States, which helps to explain the large global production and sales of pumice. In Europe, basic home construction uses significantly less gypsum wallboard because stone and concrete are the preferred building materials. Prefabricated light weight concrete walls are often produced and shipped to construction locations. Because of their lightweight, strength, and cementitious properties, pumice and pumicite perform well in European-style construction. In 2009, Greece was the leading exporter of pumice to Asia, Europe, and the United States.

Outlook

U.S. consumption of pumice and pumicite in 2010 was expected to remain static or could continue to decrease compared with that of 2009, largely owing to the status of the U.S. residential housing sector, a major user of pumice- and pumicite-related products. Imports and exports were likewise expected to remain about the same or decrease in 2010 for similar reasons.

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TABLE 1

SALIENT PUMICE AND PUMICITE STATISTICS[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

		2005	2006	2007	2008	2009
United States:						
Sold and used by producers:						
Quantity		1,270	1,540	1,270	791	410
Value[2]		39,300	44,300	28,900	15,900	12,300
Average value	dollars per metric ton	31.00	28.85	22.85	20.13	29.97
Exports[3]		15	18	9	15	11
Imports for consumption[3]		240	109	37	65	26
Apparent consumption[4]		1,490	1,630	1,290	841	425
World, production, pumice and related volcanic materials		18,300 r	20,400 r	20,700	18,900 r	17,200 e

e Estimated. r Revised.

[1] Data are rounded to no more than three significant digits, except average value.

[2] Free on board mine and (or) mill.

[3] Source: U.S. Census Bureau.

[4] Production plus imports minus exports plus adjustments for Government and industry stock changes.

TABLE 2

PUMICE AND PUMICITE SOLD AND USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

	2008			2009		
Use	Quantity (thousand metric tons)	Value (thousands)	Average unit value	Quantity (thousand metric tons)	Value (thousands)	Average unit value
Abrasives[2]	22	$1,340	$60.95	8	$78	$9.38
Building block, includes decorative block	620	7,970	12.86	239	5,540	23.13
Concrete admixture and aggregate	41	1,100	26.90	28	826	29.93
Horticulture and landscaping	46	1,790	38.89	101	2,980	29.57
Other[3]	62	3,720	60.06	34	2,870	84.97
Total or average	791	15,900	20.13	410	12,300	29.97

[1] Data are rounded to no more than three significant digits, except average unit value; may not add to totals shown.

[2] Includes cleaning and scouring compounds.

[3] Includes absorbent, diluents, fill, filter aids, laundries, pottery, and other unspecified uses.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF PUMICE, BY CLASS AND COUNTRY[1]

	Crude or unmanufactured		Wholly or partly manufactured	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2008:				
Austria	(2)	11	(2)	5
China	53	127	198	779
Germany	--	--	119	212
Greece	55,700	2,120	52	707
Iceland	5,950	230	--	--
Italy	--	--	19	39
Mexico	1,550	210	33	8
Poland	1,640	184	(2)	11
Other	47	13	15	127
Total	65,000	2,890	436	1,890
2009:				
Austria	--	--	(2)	11
China	9	49	74	307
Germany	--	--	68	70
Greece	21,000	367	20	289
Italy	--	--	(2)	3
Mexico	1,360	209	86	19
Montserrat	3,600	130	--	--
Poland	--	--	6	98
Other	68	29	4	35
Total	26,000	784	258	832

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4
PUMICE AND RELATED MATERIALS: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Algeria, pozzolan	494,000	433,190	570,000	490,567 [r]	500,000
Argentina, pumice	15,361	17,665	16,200	6,500 [r]	7,020 [4]
Austria, trass	2,943	--	--	--	--
Burkina Faso[e]	10,000	10,000	10,000	10,000	10,000
Cameroon, pozzolan[e]	600,000	600,000	600,000	600,000	600,000
Chile, pumice and pozzolan	1,620,099	1,423,144	1,135,771	1,063,176 [r]	919,000 [4]
Costa Rica[e]	8,000	8,000	--	--	--
Croatia, volcanic tuff	20,988	17,157	15,085 [r]	15,000 [r, e]	15,000
Dominica, pumice and volcanic ash[e]	100,000	100,000	100,000	100,000	100,000
Ecuador:					
Pozzolan	540,318	700,007	582,560	600,000 [e]	500,000
Pumice	107,178	8,730	153,500	150,000 [e]	100,000
El Salvador, pozzolan[e]	223,000	223,000	223,000	223,000	200,000
Eritrea, pumice	23 [r]	1,072 [r]	55 [r]	60 [r, e]	60
Ethiopia[5]	255,334	255,622	22,000 [r]	35,000 [r]	35,000
France, pozzolan and lapilli[e]	400,000	272,000	250,000	276,000	276,000
Greece:[e]					
Pozzolan, Santorin earth	1,400,000	1,400,000	1,400,000	1,059,000 [r, 4]	830,000 [4]
Pumice	850,000	850,000	850,000	828,000 [r, 4]	381,000 [4]
Guadeloupe, pumice[e]	210,000	210,000	210,000	210,000	200,000
Guatemala, pumice	82,118	447,184	220,389	395,299 [r]	394,955 [4]
Honduras, pozzolan[e]	100,000	100,000	100,000	100,000	100,000
Iceland:[e]					
Pumice	50,000	105,000 [4]	100,000	100,000	100,000
Scoria	1,000	1,000	1,000	1,000	1,000
Iran[e]	1,500,000 [4]	1,400,000	1,500,000	1,500,000	1,500,000
Italy:[e]					
Pozzolan	4,000,000	4,000,000	4,000,000	3,000,000	3,000,000
Pumice and pumiceous lapilli	28,000	20,000	20,000	20,000	20,000
Jamaica, pozzolan	--	149,279	114,482	124,304	132,470 [4]
Kosovo, volcanic tuff	-- [6]	-- [6]	-- [6]	39,631 [r, 7]	51,769 [4, 7]
Macedonia, volcanic tuff	50,000 [e]	60,000 [r, e]	80,910 [r]	103,476 [r]	113,064 [4]
Martinique, pumice[e]	130,000	130,000	130,000	130,000	130,000
New Zealand	245,080	303,659	354,903	174,729 [r]	200,000
Philippines:					
Pumice	--	1,917	1,912	2,063	2,064 [4]
Volcanic tuff	17,850	17,590	16,490	17,570	18,830 [4]
Saudi Arabia, pozzolan[e]	372,000	400,000	784,000 [4]	810,000 [r]	800,000
Serbia, volcanic tuff[e]	100,000 [8]	100,000	100,000	100,000	100,000
Slovenia, volcanic tuff[e]	40,000	40,000	40,000	40,000	40,000
Spain, including Canary Islands[e]	600,000	600,000	600,000	600,000	600,000
Syria, volcanic tuff[e]	650,000	650,000	810,000 [r]	901,000 [4]	957,639 [4]
Tanzania, pozzolanic materials	163,499	129,295	184,070	180,000 [e]	180,000
Turkey	1,860,037	3,515,644	3,995,423	4,000,000 [e]	3,500,000
Uganda, pozzolanic materials[e]	140,000	140,000	140,000	140,000	140,000

See footnotes at end of table.

TABLE 4—Continued

PUMICE AND RELATED MATERIALS: WORLD PRODUCTION, BY COUNTRY[1,2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
United States, pumice, sold and used by producers	1,270,000	1,540,000	1,270,000	791,000	410,000 [4]
Grand total	18,300,000 [r]	20,400,000 [r]	20,700,000	18,900,000 [r]	17,200,000
Of which:					
Pumice	2,710,000	3,310,000 [r]	2,950,000	2,610,000 [r]	1,720,000
Pozzolan	8,030,000	8,270,000 [r]	8,700,000 [r]	7,330,000 [r]	6,980,000
Trass and scoria	3,940	1,000	1,000	1,000	1,000
Volcanic tuff	879,000 [r]	885,000 [r]	1,060,000 [r]	1,220,000 [r]	1,300,000
Unspecified	6,630,000	7,910,000	7,990,000 [r]	7,780,000 [r]	7,160,000

[e]Estimated. [r]Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through April 21, 2010.

[3] Pumice and related materials also are produced in a number of other countries, including China, Japan, Mexico, and the Commonwealth of Independent States, but available information is inadequate for the formulation of reliable estimates of output levels.

[4] Reported figure.

[5] Data are for year ending July 7 of that stated.

[6] On February 17, 2008, the Kosovo Assembly declared independence from Serbia. Kosovo's data for 1999–2007 is not included in Serbian statistics.

[7] Coverted from reported data, in cubic meters, as follows: 2008—45,005; and 2009—58,788.

[8] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

RARE EARTHS

By Daniel J. Cordier

Domestic survey data and tables were prepared by Maria Arguelles, statistical assistant; the world production tables were prepared by Glenn J. Wallace, international data coordinator; and the map figure was designed by Robert M. Callaghan, geographic information specialist.

In 2009, world rare-earth production was primarily from the mineral bastnäsite. Rare earths were not mined in the United States in 2009. Rare-earth ores were primarily mined by China, with smaller amounts mined in India, Brazil, and Malaysia, listed in order of decreasing production. Throughout 2009, processing of intermediate rare-earth concentrates took place at the Mountain Pass Mine in California.

Domestic use of scandium decreased in 2009 and overall consumption remained small. Demand was primarily for aluminum alloys used in baseball and softball bats. Scandium alloys, compounds, and metals were used in analytical standards, metallurgical research, and sports equipment. Minor amounts of high-purity scandium were used in semiconductors and specialty lighting.

Based on import data from the Port Import Export Reporting Service (PIERS) database of Commonwealth Business Media, Inc. (undated), domestic yttrium consumption decreased by 8.8% in 2009 compared with that of 2008. Yttrium was used primarily in fluorescent lamp and cathode-ray tube (CRT) phosphors; lesser amounts were used in structural ceramics and oxygen sensors.

The rare earths are a moderately abundant group of 17 elements comprising the 15 lanthanoids, scandium, and yttrium. The elements range in crustal abundance from cerium, the 25th most abundant element of the 78 common elements in the Earth's crust at 60 parts per million (ppm), to thulium and lutetium, the least abundant rare-earth elements (REE), at about 0.5 ppm (Mason and Moore, 1982, p. 46). In rock-forming minerals, rare earths typically occur in compounds as trivalent cations in carbonates, oxides, phosphates, and silicates.

The lanthanoids (sometimes referred to as lanthanides) comprise a group of 15 elements with atomic numbers 57 through 71 that include the following in order of atomic number: lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium. Cerium, which is more abundant than copper (average concentration in the Earth's crust 50 ppm), is the most abundant member of the group at 60 ppm, followed, in decreasing order, by yttrium at 33 ppm, lanthanum at 30 ppm, and neodymium at 28 ppm. Thulium and lutetium, the least abundant of the lanthanides at 0.5 ppm, occur in the Earth's crust in higher concentrations than antimony, bismuth, cadmium, and thallium.

Rare earths can be classified as either light rare-earth elements (LREE) or heavy rare-earth elements (HREE). This division between the LREE include the lanthanide elements from atomic number 57 (lanthanum) through atomic number 64 (gadolinium) and the HREE include the lanthanide elements from atomic number 65 (terbium) through atomic number 71 (lutetium). The division is based on the lanthanoid LREE having unpaired electrons in the 4f electron shell and HREE having paired electrons in the 4f electron shell. Gadolinium has a very stable one-half filled 4f electron shell with seven unpaired electrons. Proceeding with terbium and continuing along the series through lutetium, paired electrons are progressively added to the 4f electron shell for each respective element in the HREE lanthanoid series until there is a full complement of 14 electrons in the 4f electron shell of lutetium. The division between LREE and HREE lanthanoids falls between gadolinium and terbium. Yttrium is included as a HREE even though it is not part of the lanthanoid contraction series.

Scandium (atomic number 21), a transition metal, is the lightest REE but it is not classified as one of the group of LREE nor one of the HREE. It is the 31st most abundant element in the Earth's crust, with an average crustal abundance of 22 ppm. Scandium is a soft, lightweight, silvery-white metal, similar in appearance and weight to aluminum. It is represented by the chemical symbol Sc and has one naturally occurring isotope. Although its occurrence in crustal rocks is greater than that of lead, mercury, and the precious metals, scandium rarely occurs in concentrated quantities because it does not selectively combine with the common ore-forming anions.

Yttrium (atomic number 39), a transition metal, is chemically similar to the lanthanides and often occurs in the same minerals as a result of its similar ionic radius. Its atomic radius of 104 picometers in the trivalent state places it in relative size between the ionic radii of holmium and erbium (104.1 and 103, respectively). It is included as one of the HREE. It is represented by the chemical symbol Y and has one naturally occurring isotope. Yttrium is the second most abundant rare earth in the Earth's crust. Yttrium is a bright silvery metal that is soft and malleable, similar in density to titanium.

The elemental forms of rare earths are iron gray to silvery lustrous metals that are typically soft, malleable, ductile, and usually reactive, especially at elevated temperatures or when finely divided. Melting points range from 798 °C for cerium to 1,663 °C for lutetium. The unique properties of rare earths are used in a wide variety of applications. The principal economic ores of the rare earths are the minerals bastnäsite, loparite, and monazite and the lateritic ion-adsorption clays (table 2).

Production

In 2009, the Mountain Pass operation of Molycorp Mining LLC (formerly Molycorp Minerals LLC) remained open, although rare earths were not actively mined. The company processed holdings of lanthanum-rich feedstock contained on site. Production was in the form of lanthanum-rich hydrates and neodymium-praseodymium oxides, which are precipitated as carbonates and then oxalates and finally calcined to oxide form.

Two companies processed intermediate rare-earth compounds to lanthanides in 2009. Grace Davison (a subsidiary of W.R. Grace & Co.) processed intermediate rare-earth compounds to produce cerium- and lanthanum-rich compounds used in making fluid-cracking catalysts for the petroleum refining industry. The company also processed zirconia-stabilized ceria compounds for supports for automotive catalysts, fluid catalytic cracking additives, and oxidation of organic compounds in wastewater, and produced several grades of Vitrox and Rareox cerium oxide polishing compounds. Grace Davison's Refining Technologies operating segment's sales were down 26% from those of the prior year quarter (Grace News, 2010). Sales of catalysts and chemical additives were unfavorably affected by the deconsolidation of the Advanced Refining Technologies (ART) LLC joint venture and lower sales volumes, but partly offset by improved pricing in fluid catalytic cracking (FCC) catalysts and additives. Reported sales of this product group include $17.8 million related to the ART joint venture in the fourth quarter of 2009 and $77.3 million in the prior year fourth quarter.

Santoku America, Inc. (a subsidiary of Santoku Corporation of Japan) produced rare-earth metals and magnet alloys at its operations in Tolleson, AZ. Santoku America produced two types of alloys used in high-strength permanent magnets—neodymium-iron-boron (NIB) and samarium-cobalt (SmCo)—and was the sole domestic producer of NIB magnet alloys. The plant also produced a full range of high-purity rare-earth metals, including scandium and yttrium, in cast and distilled forms, as foils, and as sputtering targets.

The only U.S. producer of rare-earth permanent magnets was Electron Energy Corp. (EEC) of Landisville, PA. EEC produced SmCo permanent magnets and designed and manufactured magnet assemblies, including actuators, Halbach arrays (magnetic field focusing assemblies), high-speed rotors, and other components.

One U.S. scandium processor operated in 2009. Aldrich-APL, LLC in Urbana, IL, purified and processed imported oxides to produce high-purity scandium compounds, including anhydrous and hydrous chloride, fluoride, iodide, and oxide. The company also produced high-purity scandium metal. High-purity products were available in various grades, with scandium oxide having up to 99.999% purity.

Boulder Scientific Co., another processor, had scandium facilities on standby at its Mead, CO, operations. Boulder Scientific previously refined scandium primarily from imported oxides and domestic ores to produce high-purity scandium compounds, including carbide, chloride, diboride, fluoride, hydride, nitride, oxalate, and tungstate.

All domestic, commercially produced, purified yttrium products were derived from imported compounds. The principal source was China.

Rare Element Resources Bear Lodge (Wyoming) is a large alkaline-igneous complex of disseminated LREE. Rare Element has continued exploring the Bull Hill carbonatite deposit with drill-hole information obtained from 2004 to 2009. Metallurgical test work has been conducted and an effort is ongoing to upgrade the National Instrument N.I. 43–101-compliant resource of the rare-earth elements deposits. The principal rare earth containing deposit is comprised of carbonatite bodies composed of unweathered sovite or silicocarbonatite dikes approximately 15 meters (m) wide cross cut by altered oxidized rare-earth-bearing iron-manganese (FMR) veins and dikes. The main rare-earth-bearing minerals are ancylite, $Sr(REE)(CO_3)_2(OH)(H_2O)$, and bastnaesite, $(REE)CO_3(F,OH)$. A N.I. 43–101-compliant inferred mineral resource reportedly was estimated for the Bull Hill Southwest deposit using a cutoff grade of 1.5%. This estimate totaled 9.8 million metric tons (Mt) averaging 4.1% total rare-earth oxides (TREO) (Rare Element Resources Ltd., 2009).

In previous U.S. Geological Survey Minerals Yearbook chapters, resources in other States are described. Information on reserves and deposits in Alaska and Utah is published in the 2008 Rare Earths chapter of the U.S. Geological Survey Minerals Yearbook, volume I, Metals and Minerals, and information on reserves and deposits in Colorado, Idaho, Montana, Missouri, and Wyoming is published in the U.S. Geological Survey Minerals Yearbook 2007 Rare Earths chapter.

Consumption

Data on domestic rare-earth consumption were developed by surveying various processors and manufacturers, evaluating import and export data, and analyzing U.S. Government stockpile shipments. Domestic apparent consumption of rare earths was not calculated in 2009 because data were withheld to avoid disclosing company proprietary data.

In 2009, yttrium consumption was estimated to have decreased to 448 metric tons (t) from 616 t in 2008. Yttrium information was based on data retrieved from the Port Import Export Reporting Service database. Yttrium compounds and metal were imported from the following sources in 2009: China (90%), Austria (4%), Japan (3%), and Belgium (3%). The estimated use of yttrium, based on imports, was primarily in fluorescent lamp and CRT phosphors, ceramics, and specialty alloys, with a minor amount for metal casting (Commonwealth Business Media, Inc., undated).

Stocks

The last of the U.S. Government stocks of rare earths in the National Defense Stockpile (NDS) was shipped in 1998. Periodic assessments of the national defense material requirements may result in the inclusion of rare earths, including scandium and yttrium, in the NDS at a future date.

Prices

The prices of most rare-earth materials, as provided by Rhodia Group of France quoted rare-earth oxide (REO) prices, net 30 days, free on board New Brunswick, NJ, or duty paid at point of entry, in effect at yearend 2009, were lower or the same in 2009 compared with those of 2008 (table 3). All rare-earth prices remained nominal and subject to change without notice. The competitive pricing policies that are in effect for the industry result in most rare-earth product prices being quoted on a daily basis from the producers and processors. Domestic prices were higher than Chinese prices because of shipping costs related to its classification as a pyrophoric hazardous material. Prices for monazite remained depressed from their historical levels because the principal international rare-earth processors continued to process only thorium-free feed materials.

In 2009, Rhodia provided prices for scandium in the years of 2008 and 2009. Prices in 2009 were lower for the high-purity oxides and mid- to ultrahigh-purity oxides than the prices for those materials in 2008.

Prices for kilogram quantities of scandium metal in ingot form have historically averaged about twice the price of scandium oxide, and higher purity distilled scandium metal prices have averaged about five times that price.

In the following discussion, where necessary, values have been converted from the Chinese Yuan Renminbi to U.S. dollars at exchange rates for the date of posting of each reference cited concerning those nominal values.

With the founding of Inner Mongolia Baogang Rare Earth International Trading Co., Ltd. in December 2008, pricing of rare-earth raw material began to stabilize in Northern China. In 2008 the global rare-earth market was stagnant, and many Chinese rare-earth enterprises did not operate at full production in the first half of 2009, which led to a low supply of yttrium-medium and europium-rich minerals in southern China. However, the market rebounded in the second half of 2009. Price of yttrium and europium minerals increased from a range of $5,700 to $6,300 per metric ton at the beginning of the year to $9,500 to $9,700 per ton at yearend in 2009, an annual growth rate of 70% (China Rare Earth Information, 2010a).

Owing to low demand in 2008 in the automobile sector, demand for neodymium iron boron (NdFeB) magnets decreased in the United States and Europe. In 2009, demand for NdFeB permanent rare-earth magnets began to recover and prices of rare earths increased. The highest price of didymium (a mixture of the elements praseodymium and neodymium) oxide in 2009 was $17,600 per ton, an increase of 150% more than the yearend price of 2008, but was still 30% lower than the highest price of 2008. Price of didymium mischmetal also increased from $11,700 per ton at the beginning of 2009 to $23,500 per ton, a growth rate of 100%. The price of cerium oxide kept rising in 2009, from a range of $1,600 to $1,800 per ton at the beginning of the year to $2,900 per ton in December, an increase of 80%. Demand for other cerium related products such as cerium chloride, remained stable, but prices for those products increased. In 2009, the price of lanthanum oxide decreased from a range of $4,000 to $4,400 per ton at the beginning of 2009 to $3,100 to $3,200 per ton through June, a decrease of 30%, but then recovered to a price range of $4,100 to $4,400 per ton by yearend, still below year-average prices of 2008 (China Rare Earth Information, 2010a).

Rare-earth carbonate was in short supply and began to increase in price significantly during the second half of 2009. After the first half of 2009, the price of yttrium and europium minerals increased from a range of $6,300 to $7,900 per ton to $7,800 to $8,700 per ton. From January to December 2009, prices of neodymium oxide, didymium oxide, neodymium metal, and didymium metal increased from $10,000 to 19,800 per ton (98%), $8,500 to $18,400 per ton (116%), $13,600 to $25,000 per ton (84%), and $12,000 to $24,200 per ton (101%), respectively (China Rare Earth Information, 2010d).

Foreign Trade

U.S. exports of rare earths increased and imports decreased with regard to quantity in 2009 compared with those of 2008. Data in this section are based on gross weight, while data in the tables may be converted to equivalent REO content, as specified. U.S. exports totaled 8,746 t valued at $58 million, approximately a 6% increase in quantity and a 3% decrease in value compared with those of 2008 (table 4). Imports totaled 15,000 t, gross weight, valued at $113 million, an almost 28% decrease in quantity and a 39% decrease in value compared with those of 2008 (table 5).

In 2009, U.S. exports of rare earths decreased in quantity in three out of four trade categories. The United States exported 4,100 t of rare-earth metals valued at $15.7 million, a 255% increase in quantity and a 15% decrease in value compared with that of 2008. Exports of cerium compounds, primarily for glass polishing and automotive catalytic converters, decreased in quantity by 39% to 840 t and decreased in value by 34% to $8 million.

Exports of inorganic and organic rare-earth compounds decreased by 31% to 455 t in 2009 from 663 t in 2008, and the value of the shipments decreased by 18% to $6.2 million from $7.6 million.

U.S. exports of ferrocerium and other pyrophoric alloys decreased by 34% to 3,350 t valued at $28 million in 2009 from 5,050 t valued at $21.2 million in 2008.

Mischmetal and specialty mischmetals comprised most of the U.S. rare-earth metal imports. (Mischmetal is a natural mixture of rare-earth metals typically produced by metallothermic reduction of a mixed rare-earth chloride).

In 2009, U.S. imports of compounds and alloys decreased in quantity for six out of the seven categories listed in table 5. China dominated the import market, especially for mixed and individual rare-earth compounds, except for the category of ferrocerium and other pyrophoric alloys, where France dominated. In decreasing order of import quantity, the leading supply countries were China, France, Austria, and Japan. These five countries accounted for 95% of the domestic imports.

Imports of cerium compounds totaled 2,200 t valued at $9.1 million. The quantity of cerium compounds imported decreased by 28% as a result of a decreasing demand for automotive exhaust catalysts, and the value decreased by 29%. China was the major supplier for the 14th consecutive year, followed by Austria, Japan, the United Kingdom, and France.

Imports of yttrium compounds that contained between 19 and 85 weight-percent yttrium (yttrium concentrate) decreased by 30% to 11.5 t in 2009, and the value decreased by 92% to $565,000. China was the leading supplier of yttrium compounds, followed by Japan and France.

Imports of individual rare-earth compounds, traditionally the major share of rare-earth imports, decreased by 42% compared with those of 2008. Rare-earth compound imports decreased to 6,800 t valued at $67.5 million, a decrease in value of 43%. The major sources of individual rare-earth compounds, in decreasing order by quantity, were China, France, Japan, Austria, South Africa, and Germany.

In 2009, imports of mixtures of REOs, other than cerium oxide, increased in quantity by 98% to 4,750 t in 2009 from 2,390 t in 2008, and increased in value 4% to $23.5 million. The principal source of the mixed REOs was China, with much smaller quantities, in decreasing order of tonnage, imported from Italy, Japan, and Germany.

Imports of rare-earth metals and alloys into the United States totaled 188 t valued at about $4.9 million in 2009, a 67% decrease in quantity compared with that of 2008. The value also decreased slightly from that of the previous year. The principal rare-earth metal source was China, with much smaller amounts, in decreasing order of tonnage, from Japan, the United Kingdom, Russia, and Austria.

In 2009, imports of rare-earth chlorides decreased by 69% to 894 t, and the value decreased by 72% to $4.9 million. Supplies of rare-earth chloride, in descending order by quantity, came from China, with minor amounts from Japan, the United Kingdom, and others. In the United States, rare-earth chloride was used mainly as feed material for manufacturing fluid-cracking catalysts.

Imports of ferrocerium and pyrophoric alloys decreased by 19% in quantity to 114 t, with a 10% increase in value at $2.6 million from 141 t valued at $2.4 million in 2008. Principal sources of these alloys were, in descending order by quantity, France, Austria, and China.

World Review

Supply of cerium oxide was restricted in the market, driven by a stable demand in the glass industry; China's centralized sales of Baogang Rare Earth International Trading Co., Ltd.'s products from major separation plants in northern China; and reduced supply of rare-earth products by the separation plants. In the first half of 2009, China reduced the price of crude oil, which led to a decrease in demand for lanthanum oxide used in fluid catalytic cracking by the petroleum industry. Outside of China, however, the petroleum refinery industry began to replenish stock inventories, which resulted in an increase in demand. Early in 2009, there was a reduction in the demand for phosphor yttrium and europium products that increased slightly by the yearend (China Rare Earth Information, 2010a).

Australia.—Arafura Resources Ltd. and the Jiangsu Eastern China Non-Ferrous Metals Investment Holding Company signed an equity investment agreement delivering Jiangsu [a subsidiary of the East China Exploration and Development Bureau (ECE)], up to a 25% interest in Arafura. The proceeds from the ECE investment were to be used for developing the company's Nolans Rare Earths-Phosphate-Uranium Project in the Northern Territory (Arafura Resources Ltd., 2009).

West Australian Alkane Resources Ltd. reported a measured resource of 37.5 Mt and an inferred resource totaling 73.2 Mt grading 0.14% yttrium oxide, and 0.75% REO. Also, Dubbo Zirconia Project in New South Wales recently produced its first rare-earth and yttrium-heavy rare-earth products from the demonstration pilot plant at Lucas Heights, located south of Sydney. The planned open pit resource was expected to have a mine life of up to 200 years, with alternative plans for a mining rate of 200,000 or 500,000 metric tons per year (t/yr) yielding 1,300 t/yr or 3200 t/yr of TREO, respectively (Alkane Resources Ltd., 2009).

Lynas Corporation Ltd., owner of the Mount Weld rare-earth deposit near Laverton in Western Australia, signed a binding heads agreement with China Nonferrous Metal Mining (Group) Company Ltd. (CNMC) in May 2009 for provision of a multimillion dollar investment to renew construction and commissioning of its mine in Australia and processing plant in Malaysia. Lynas Malaysia Sdn Bhd (a subsidiary of Lynas Corp.) also had an advanced materials plant for processing the mine concentrates from Mount Weld under construction in the Gebeng Industrial Estate in Kuantan, Pahang, Malaysia. In September 2009, CNMC terminated the deal after Australia's Foreign Investment Review Board (FIRB) insisted on reducing CNMC's proposed stake in Lynas from 51.6% to less than 50% and reducing its Board positions to less than one-half. Lynas renewed the search for fresh sources of funding for the mine and processing plant, which has been on care-and-maintenance status since February (West Australian, The, 2009).

At Jervois Mining Ltd.'s (Melbourne) The Gilgai resource, 25 kilometers (km) from Nyngan, which is about 160 km northwest of Dubbo, New South Wales, a total measured plus indicated scandium resource at the Nyngan deposit was reported to be about 12,000,000 t of ore with a grade of 261 ppm scandium. The deposit was considered minable via open pit method, with the capacity of producing 30 t/yr of 99.9% scandium oxide. The proposed open mine pit and treatment facility would be positioned on land owned by Jervois (Jervois Mining Ltd., 2009).

Canada.—Matamec Explorations Inc. completed the 2009 drilling campaign on the heavy rare-earth-yttrium-zirconium Kipawa deposit located on the Zeus property in the Kipawa Alkaline Complex in Temiscamingue, Quebec. The deposit occurred across most of the Kipawa Alkaline complex, which was hosted in a peralkaline syenite and granite about 200 m thick. Metamec acquired deposit holdings of its present size of 259 claim cells in April 2009. At Kipawa, mineralization is contained in three main minerals in decreasing order of rare earth abundance: eudialyte, britholite, and zircon, which is a mineralogy similar to other major deposits not currently in production, such as the Lovozero and Khibiny loparite massifs of Russia, the Ilimaussaq intrusion located in east Greenland, and the Parajito Mountain deposit of New Mexico. Historical resources calculated by Unocal in 1991 were estimated to be 1.26 Mt at grades of 0.15% yttrium oxide in the west zone, and 1.009 Mt at 0.14% Y_2O_3 and 1.01 Mt at a grade of 0.14% Y_2O_3 in the east zone.

China.—Mine production of REE was primarily from bastnäsite and other rare-earth minerals in Inner Mongolia and Sichuan Province, and from ion adsorption ore in the southeastern Provinces of Fujian, Guangdong, and Jiangxi (Grauch and Mariano, 2008).

About one-third of all rare earths produced in China were consumed by the iron and steel industries. Principal products were rare-earth-ferrosilicon (rare-earth-silicide) and rare-earth-magnesium-ferrosilicon.

In December 2008, the first batch of export quotas was released for 2009 and was set at 15,000 t granted to 20 enterprises that met application conditions based on export performances between 2006 and 2008 (China Rare Earth Information, 2009a). On June 29, 2009, in accordance with regulations on import and export of mineral commodities, the Ministry of Commerce released the second batch of rare-earth export quotas of 16,300 t of rare-earth minerals (China Rare Earth Information, 2009b).

By comparison, in 2008, the rare-earth export quota was 22,780 t in the first tranche (half-year quantity) and 11,376 t in the second tranche. It totaled 34,156 t in 2008. In 2009, the total export quota for common trade was 33,300 t, including 15,043 t in the first tranche, and 16,267 t in the second tranche along with 1,990 t of supplemented quotas. The quota decreased by 856 t in 2009, which was a decrease of 3% (China Rare Earth Information, 2010b).

Chinese exports of rare-earth metals to Japan fell sharply in 2008. Exports of neodymium oxide decreased in 2009 by 21%. Exports of terbium dropped by 74% to as low as 2.48 t and exports of dysprosium almost ceased. Chinese exports of other ferroalloys to Japan increased by 32% to 25,000 t in 2008 (Roskill's Letters from Japan, 2009d).

The Chinese Government also issued production quotas for rare earths in 2009. The light rare-earths quota was 72,300 t REO equivalents. The medium and heavy rare-earths quotas were 10,020 t REO equivalents. The total 2009 quota was 82,320 t REO (Roskill's Letters from Japan, 2009d).

China Rare Earth Holdings Limited announced a joint venture with OSRAM of Siemens in October 2009 to research, develop, and produce trichromatic phosphors with a capacity of up to 2,000 t upon completion of operations (China Rare Earth Information, 2009c).

In the Chinese domestic market, rare-earth consumption in the steel industry increased to 10,400 t, comprising 15.3% of China's total rare-earth consumption in 2008. To place this in perspective, in 2008, the total amount of rare-earth treated steel that was produced was nearly 1.65 Mt. Private enterprises produced 750,000 t, representing 45.4%, the balance produced by state-owned steel plants in China (China Rare Earth Information, 2010c).

In 2009, Inner Mongolia Baotou Steel Rare Earth (RE) International Trade Company began formal business operations with the implementation of a centralized purchase and marketing strategy for rare-earth oxides and metals produced in Baotou. Baogang Group (Inner Mongolia region-based Chinese steelmaker Baotou Iron and Steel), the largest iron and steel production center in China, began large volume export of steel rail to the Americas in 2009. Production of steel in Baogang was 10 Mt in 2009. Export of 59,000 t of 115 RE rail steel produced in 2009 was shipped to North America and South America (China Rare Earth Information, 2010e).

The Chinese domestic market had strong demand for permanent rare-earth magnets in 2009. Production and consumption in this sector were 55,000 t and 23,000 t, which were increases of 13% and 14%, respectively, from that of 2008. Magnet exports, totaling 9,400 t, decreased by 13% from that of 2008 (China Rare Earth Information, 2010d).

Beginning in 2008, the Chinese Government had taken significant steps to promote rare-earth (RE) three-prime color lights. RE tricolor lamps, including RE compact fluorescent lamps and RE tubular T5 and T8 lamps, were promoted as primary products in the medium and long term energy-saving program of the State, especially in government buildings. In April 2009, the Economic and Construction Department of the Ministry of Finance and Energy Saving, and the Environmental Protection Department of the National Development and Reform Commission, announced the "tender results for high efficiency illumination product promotion project." There was an increase from 13 to 22 enterprises that were subsidized by the Government in this project for consumption of 50 million energy saving lamps in 2008 to 120 million units in 2009. Output of RE tricolor phosphors in China were 5,500 t in 2008 and production exceeded 6,000 t in 2009, an increase of 9%. Approximately one ton of rare-earth tricolor phosphor can be used to produce 3 million T2–8W spiral fluorescent tubes (China Rare Earth Information, 2010f).

A 15% export tax was also imposed on exports of ferroalloys in December 2008. The Chinese Government reduced export quotas for rare earths in the first half of 2009. Quotas for Chinese companies have been cut by 34% year-on-year between 2008 and 2009 to 15,000 t, while quotas for companies with foreign investment were reduced by 19% to 6,600 t (Roskill's Letters from Japan, 2009d).

France.—Rhodia was organized into seven enterprises, with the rare-earth unit, Rhodia Electronics and Catalysis, and the performance silica unit, Rhodia Silica Systems, under Rhodia Silcea. Rhodia produced rare-earth-containing catalysts for automotive emission applications, fluid-cracking catalysts for oil refining, desulfurization catalysts, styrene monomer catalysts, chemical catalysts for oxidation, catalysts for dehydrogenation and hydrogenation, and polymerization catalysts used in paints and tires. Rhodia's other operations produced high-purity rare earths at its separation plant in La Rochelle. Additional rare-earth capacity was operated through Anan Kasei in Kobe, Japan.

Japan.—There were three Japanese NIB alloy producers, one of which used neodymium exclusively, with the other two using didymium, a mixture of mostly neodymium and praseodymium.

Toyota Tsusho, a trading house affiliated with Toyota Motor, showed interest in developing the Dong Pao bastnaesite deposit in Northern Vietnam which has elevated LREE content that would be used in the production of magnets for hybrid electric vehicles produced by Toyota Motor. In November 2009, Toyota Tsusho purchased Wako Bussan that had sales rights for rare earths produced by the state-owned Indian Rare Earths Ltd. (IREL) in India. The company was renamed Toyotsu Rare Earths and established their headquarters at Toyota Tsusho's main office in Marunouchi, Tokyo. IREL planned to restart production of rare-earth oxides in 2010. In the first quarter of 2009, Toyota Tsusho announced signing a memorandum of understanding with VINACOMIN Group to acquire 49% of mining rights at the Dong Pao deposit and all of the product sales rights (Roskill's Letters from Japan, 2009a).

Showa Denko (SDK) started a new company in Vietnam named Showa Denko Rare Earth Vietnam in October 2008, with 90% ownership, leaving 10% to Tokai Trade. In 2009, SDK had a total capacity for producing 8,000 t/yr of rare-earth magnet alloys. The breakdown of production was 5,000 t at the Chichibu plants in Japan, along with 1,000 t at Baotou Showa

Rare Earth Hi-tech New Material in Inner Mongolia, and 2,000 t at Ganzhou Zhaori Rare Earth New Material in Jiangxi Province (Roskill's Letters from Japan, 2009a).

Bonded rare-earth magnets by Japanese producers worldwide decreased by 5% in 2008, and the value of overseas production dropped by 7%. This was the first published reduction in production (Roskill's Letters from Japan, 2009b).

During 2008, average prices of Japanese imports of light rare earths increased, specifically for cerium, lanthanum, and samarium. The price increases were attributed to the strengthening of export regulations by the Chinese government. Prices of magnet raw materials decreased during 2008, reflecting lower demand for neodymium-iron boron (NdFeB) magnets in China and in electronic products and vehicles in Japan since the summer of 2008. The average value of Chinese exports of neodymium peaked in September 2007, but was reduced to one-half from $40 per kilogram in July 2008, to $19 per kilogram in December 2008 (Roskill's Letters from Japan, 2009c).

Japanese imports of rare earths decreased by 13% to 35,000 t in 2008, including the largest decrease ever for rare-earth metals, which declined by 6,300 t (32%). The decrease was owing to lower demand for magnets, phosphors and polishing materials used in the automotive and electronics industries at yearend, and a buildup of stocks by Japanese buyers in 2007 anticipating stricter Chinese export regulations. Japanese demand for rare-earth metals in neodymium-iron-boron magnets and hydrogen storage alloys remained stable in 2008. Demand for neodymium-iron-boron magnets increased at a rate of 20% from the year to date through October 2007 until October 2008, and then decreased in November 2008. Production of NdFeB magnets totaled 10,500 to 11,000 t, consuming some 18,000 t of magnet alloys in 2008. Magnet alloys contained some 27% to 28% didymium and 3% dysprosium; and therefore, Japanese consumption of these metals was estimated to be 4,600 to 5,000 t and 600 to 700 t, respectively, in 2008. Japanese production of hydrogen storage alloys used in nickel-metal hydride batteries totaled 7,000 to 8,000 t in 2008. The alloys contained nearly 30% mischmetal; Japanese consumption of mischmetal in this market was estimated to be 2,500 t in 2008. Approximately 1,000 to 2,000 t of mischmetal was used as steel additives. Production of hybrid electric vehicles (HEVs) by Japanese producers increased by 7% compared with that of 2007. This was equal to 460,000 vehicles in 2008. An HEV was estimated to require 1 kilogram (kg) of neodymium-iron-boron magnets on average. Demand for rare earths in this market was forecast to rise, although from a low base. Honda reported record sales of Insight HEVs in February 2009, and Toyota initiated sales of its third generation Prius in May. Japanese demand for yttrium oxide in phosphors remained steady until August 2008, and then decreased. Japanese consumption of rare-earth oxides in phosphors was estimated to be 700 to 800 t yttrium oxide, 60 to 65 t europium oxide, and 50 to 55 t terbium oxide in 2008. Chinese exports of europium oxide to Japan rose by 160% to 104 t in 2008, but the average value of exports dropped. Consumption of cerium oxides and compounds in polishing materials remained stable. Japanese production of liquid crystal display (LCD) glass decreased between January and March 2009. Japanese optical glass producers have relocated their production bases to China. Japanese production of ceramic capacitors decreased in 2008 along with lanthanum oxide in dielectrics (Roskill's Letters from Japan, 2009d).

Japanese prices for imported neodymium, praseodymium, and didymium increased briefly by 10% in April 2009 and then decreased by 2% to 4% in May before leveling off in June. There was little trade between China and Japan in the first half of 2009. Total Chinese exports of rare-earth metals decreased by 72% year-on-year for the period January through May. Chinese exports of neodymium metal decreased by 57% year-on-year to 556 t, while exports of other metals dropped by 78% to 99%. Chinese exports of terbium were only 25 kg in January through May 2009. Exports of cerium compounds also decreased by 56% year-on-year to 2,667 t in the first 5 months of 2009, while exports of other rare-earth compounds decreased by 75% to 2,673 t (Roskill's Letters from Japan, 2009e).

Japanese prices of imported magnetic rare-earth materials—neodymium, praseodymium, and didymium—rose by 23% to 25% in November 2009 compared with prices at yearend 2008. Demand for neodymium in neodymium-iron-boron magnets in China, a principal competitive market for Japanese production, increased in April and had recovered to 80% of its peak level. Production rates in Japan recovered to 60% to 70% of capacity in October 2009. Chinese exports of rare earths to Japan fell by 43% year-on-year between 2008 and 2009 to 22,742 t in January through October. The average value of exports of rare-earth metals and compounds dropped by 46% to 47% year-on-year (Roskill's Letter from Japan, 2010).

Vietnam.—The Dong Pao Mine in the northern part of Vietnam has large resources of rare earths. The ownership included six Vietnamese companies. VIMICO (Vietnam National Minerals) and VINACOMIN (Vietnam National Coal-Mineral Industries Group) jointly held 55% of the shares. The mining rights were owned by LARESCO and Lai Chau Rare Earth in a joint venture. Two other Japanese companies—Toyota Tsusho and Sojitz—also held an interest in the Dong Pao Mine (Roskill's Letters from Japan, 2010).

Outlook

Rare-earth use in automotive pollution control catalysts, permanent magnets, and rechargeable batteries is expected to continue to rise as future global demand for conventional and hybrid automobiles, computers, electronics, and portable equipment increases. Rare-earth markets are expected to require greater amounts of higher purity mixed and separated products to meet the demand. Demand for cerium and neodymium for use in automotive catalytic converters and catalysts for petroleum refining was expected to increase for the next 5 years (Kingsnorth, 2008). Rare-earth magnet production worldwide was expected to decrease to 58,000 t in 2009, with 23,300 t of contained RE oxides, from a level of 66,000 t in 2008, distributed mostly to NdFeB magnets, and to a lesser extent SmCo magnets. Production was projected to have a compound annual growth rate (CAGR) of 8% to 9% through the next 5 years, increasing to 86,000 t by 2014 (BCC Research, 2009). Future growth was expected for rare earths in rechargeable NiMH batteries, especially those used in hybrid vehicles, increasing from 11,000 t in 2009 to 26,000 t REO by 2014, with a CAGR of 18% (BCC Research, 2009). NiMH demand was also expected to increase (moderated by increasing demand for lithium-ion batteries), with increased use in portable equipment, such as camcorders, cellular telephones, compact disk players, digital cameras, digital video disk players, laptop computers, and MPEG audio-layer-3 players. Increased rare-earth use was expected in fiber optics, medical applications that include dental and surgical lasers, magnetic resonance imaging, medical contrast agents, medical isotopes, and positron emission tomography scintillation detectors. Ceramics consumption of 7,000 to 8,000 t REO in 2010, with a CAGR of 9%, was forecast from a base level of 5,500 t REO in 2006 in applications such as high temperature strength material ceramics, electrical and electronic ceramics, and engineering ceramics such as yttria-stabilized-zirconia (YSZ), with yttrium oxide accounting for as much as 5,000 to 6,000 t of 2010 ceramic use (Roskill Information Services Ltd., 2007).

World reserves are sufficient to meet forecast world consumption well into the 21st century. Several large rare-earth deposits in Australia and China (for example, Mianning in China and Mount Weld in Australia) have yet to be fully developed. Existing production is currently not sufficient to meet world demand, and shortages exist for neodymium and dysprosium for magnet alloys and europium and terbium for phosphors. Although the Mountain Pass deposit in the United States contains sufficient resources to meet domestic demand for light-group REEs, the deposit does not contain sufficient HREE to meet demand for those elements.

All domestic and most foreign companies have currently shifted away from using naturally occurring radioactive rare-earth ores. This trend has a negative impact on monazite-containing mineral sands operations worldwide, causing mine closures and reduced revenues. Long-term demand for monazite, however, is expected to increase because of the mineral's abundant supply and low-cost byproduct recovery. Thorium's use as a nonproliferative nuclear fuel is considered a likely substitute for uranium in the future. If consumption of thorium increases, monazite could resume its role as a major source of rare earths. Storage requirements and permits to dispose of radioactive waste products in the United States are expensive, however, severely limiting domestic use of low-cost monazite and other thorium-bearing rare-earth ores.

Rare-earth producers outside of China, generating less than 5% of the world's supply, were in competition with China's lower wages, inexpensive utilities, and less restrictive environmental and permitting requirements. China was expected to remain a major world rare-earth supplier. Increasing prices, export limits, rising demand within China, and a ban on new mining permits in China were expected to make rare-earth deposits outside of China more economic. China's export quotas in 2009 were reduced from levels in 2008. Economic growth in several developing countries could provide new and potentially large markets for rare earths in eastern Europe, India, and southeastern Asia.

The long-term outlook appears to be for an increasingly competitive and diverse group of rare-earth suppliers. As research and technology continue to advance the knowledge of rare earths and their interactions with other elements, the economic base of the rare-earth industry is expected to continue to increase. New applications are expected to continue to be discovered and developed, especially in areas that are considered essential, such as energy and defense.

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TABLE 1

SALIENT U.S. RARE EARTH STATISTICS[1]

		2005	2006	2007	2008	2009
Production of rare-earth concentrates, rare-earth oxide (REO) basis[e, 2]	metric tons	--	--	--	--	-
Exports, REO basis:						
Cerium compounds	do.	2,220	2,010	1,470	1,380	840
Rare-earth metals, scandium, yttrium	do.	636	611	1,470	1,390	4,930
Rare-earth compounds, organic or inorganic	do.	2,070	2,700	1,300	663	455
Ferrocerium and pyrophoric alloys	do.	4,320	3,710	3,210	4,490	2,970
Imports for consumption, REO basis:[e]						
Cerium compounds	do.	2,170	2,590	2,680	2,080	1,500
Ferrocerium and pyrophoric alloys	do.	130	127	123	125	102
Metals, alloys, oxides, other compounds	do.	13,000	16,000	15,000	13,200	10,500
Prices, yearend:						
Bastnäsite concentrate, REO basis[e]	dollars per kilogram	5.51	6.06	6.61	9.00 [r]	9.00
Monazite concentrate, REO basis[e]	do.	0.73	0.73	0.73	0.48	0.48 [e]
Mischmetal, metal basis[3]	do.	5.00–6.00 [r]	5.00–6.00 [r]	7.00–8.00	10.00	10.00 [e]

[e]Estimated. [r]Revised. do. Ditto. -- Zero.

[1]Data are rounded to no more than three significant digits.

[2]Includes only the rare earths derived from bastnäsite as obtained from Molycorp, Inc.

[3]Source: Hefa Rare Earths Canada Co. Ltd., Vancouver, British Columbia, Canada.

TABLE 2

RARE EARTH CONTENTS OF MAJOR AND POTENTIAL SOURCE MINERALS[1]

(Percentage of total rare-earth oxide)

	Bastnäsite		Monazite			
Rare earth	Mountain Pass, CA, United States[2]	Bayan Obo, Inner Mongolia, China[3]	North Capel, Western Australia[4]	North Stradbroke Island, Queensland, Australia[5]	Green Cove Springs, FL, United States[6]	Nangang, Guangdong, China[7]
Cerium	49.10	50.00	46.00	45.80	43.70	42.70
Dysprosium	trace	0.1	0.7	0.60	0.9	0.8
Erbium	trace	trace	0.2	0.2	trace	0.3
Europium	0.1	0.2	0.053	0.8	0.16	0.1
Gadolinium	0.2	0.7	1.49	1.80	6.60	2.00
Holmium	trace	trace	0.053	0.1	0.11	0.12
Lanthanum	33.20	23.00	23.90	21.50	17.50	23.00
Lutetium	trace	trace	trace	0.01	trace	0.14
Neodymium	12.00	18.50	17.40	18.60	17.50	17.00
Praseodymium	4.34	6.20	5.00	5.30	5.00	4.10
Samarium	0.8	0.8	2.53	3.10	4.90	3.00
Terbium	trace	0.1	0.035	0.3	0.26	0.7
Thulium	trace	trace	trace	trace	trace	trace
Ytterbium	trace	trace	0.1	0.1	0.21	2.40
Yttrium	0.10	trace	2.40	2.50	3.20	2.40
Total	100	100	100	100	100	100
	Monazite—Continued		Xenotime		Rare earth laterite	
	Eastern coast, Brazil[8]	Mount Weld, Australia[9]	Lahat, Perak, Malaysia[2]	Southeast Guangdong, China[10]	Xunwu, Jiangxi Province, China[11]	Longnan, Jiangxi Province, China[11]
Cerium	47.00	51.00	3.13	3.00	2.40	0.4
Dysprosium	0.4	0.2	8.30	9.10	trace	6.70
Erbium	0.1	0.2	6.40	5.60	trace	4.90
Europium	0.1	0.4	trace	0.2	0.5	0.10
Gadolinium	1.00	1.00	3.50	5.00	3.00	6.90
Holmium	trace	0.1	2.00	2.60	trace	1.60
Lanthanum	24.00	26.00	1.24	1.20	43.4	1.82
Lutetium	not determined	trace	1.00	1.80	0.1	0.4
Neodymium	18.50	15.00	1.60	3.50	31.70	3.00
Praseodymium	4.50	4.00	0.5	0.6	9.00	0.7
Samarium	3.00	1.80	1.10	2.20	3.90	2.80
Terbium	0.1	0.1	0.9	1.20	trace	1.30
Thulium	trace	trace	1.10	1.30	trace	0.7
Ytterbium	0.02	0.1	6.80	6.00	0.3	2.50
Yttrium	1.40	trace	61.00	59.30	8.00	65.00
Total	100	100	100	100	100	100

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

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TABLE 3

RARE-EARTH OXIDE PRICES IN 2009[e]

Product (oxide)	Purity (percentage)	Standard package quantity (kilograms)	Price (dollars per kilogram)
Cerium	96.00	20	30.00
Do.	99.50	20	30.00
Dysprosium	99.00	20	170.00
Erbium	96.00	20	100.00
Europium	99.99	20	1,600.00
Gadolinium	99.99	20	150.00
Holmium	99.90	10	750.00
Lanthanum	99.99	20	30.00
Lutetium	99.99	1 or 10	1,800.00
Neodymium	95.00	20	42.00
Praseodymium	96.00	20	38.00
Samarium	99.90	20	130.00
Do.	99.99	20	130.00
Scandium	99.99	NA	2,500.00
Terbium	99.99	20	900.00
Thulium	99.90	5	1,500.00
Ytterbium	99.00	10	325.00
Yttrium	99.99	20	44.00

[e]Estimated. Do. Ditto. NA Not available.

Source: Rhodia Electronics & Catalysis, Inc.

TABLE 4

U.S. EXPORTS OF RARE EARTHS, BY COUNTRY[1]

Category[2] and country	2008 Gross weight (kilograms)	2008 Value	2009 Gross weight (kilograms)	2009 Value
Cerium compounds (2846.10.0000):				
Australia	--	--	1,920	$13,300
Austria	104,000	$708,000	43,800	437,000
Belgium	1,950	28,300	1,800	21,800
Brazil	8,690	65,800	11,400	95,900
Canada	15,300	149,000	15,300	151,000
China	72,400	893,000	72,800	878,000
Egypt	116,000	606,000	--	--
France	18,100	169,000	3,950	47,200
Germany	120,000	1,040,000	94,800	731,000
Hong Kong	20,200	251,000	3,930	128,000
India	41,700	292,000	60,600	402,000
Japan	226,000	1,850,000	114,000	1,320,000
Korea, Republic of	248,000	288,000	15,800	79,400
Mexico	82,200	423,000	192,000	800,000
Netherlands	48,800	337,000	43,300	241,000
Singapore	--	--	10,100	64,600
Taiwan	77,900	3,290,000	7,340	96,700
United Kingdom	14,500	179,000	14,200	99,500
Other	168,000	1,640,000	133,000	2,430,000
Total	1,380,000	12,200,000	840,000	8,030,000
Total estimated equivalent rare-earth oxide (REO) content	1,380,000	12,200,000	840,000	8,030,000
Rare-earth compounds[3] (2846.90.0000):				
Argentina	40	10,000	20	5,000
Austria	2	12,000	491	3,470
Brazil	59,800	258,000	13,400	122,000
Canada	48,200	773,000	53,900	479,000
China	134,000	311,000	43,200	488,000
Colombia	17,100	35,900	1,640	29,200
France	50,600	1,340,000	28,500	543,000
Germany	11,700	525,000	18,200	502,000
Guatemala	2,000	4,910	211	6,980
Hong Kong	10	6,000	2,050	125,000
India	4,960	47,900	4,190	49,600
Italy	9,730	86,100	8,110	89,700
Japan	27,400	1,030,000	63,900	1,870,000
Korea, Republic of	164,000	857,000	74,000	405,000
Mexico	40,800	850,000	43,900	502,000
Netherlands	17,000	197,000	9,370	44,400
Poland	309	37,900	164	3,700
Singapore	3,880	72,500	6,190	94,500
Taiwan	3,060	246,000	1,810	46,800
United Kingdom	32,600	381,000	3,620	229,000
Other	35,500	530,000	78,100	579,000
Total	663,000	7,610,000	455,000	6,210,000
Total estimated equivalent REO content	663,000	7,610,000	455,000	6,210,000

See footnotes at end of table.

TABLE 4—Continued

U.S. EXPORTS OF RARE EARTHS, BY COUNTRY[1]

Category[2] and country	2008 Gross weight (kilograms)	2008 Value	2009 Gross weight (kilograms)	2009 Value
Rare-earth metals, including scandium and yttrium (2805.30.0000):				
Belgium	4,850	$193,000	268	$24,600
Brazil	86	64,600	16,800	221,000
China	114,000	1,630,000	365,000	1,370,000
Germany	50,000	398,000	4,800	232,000
Hong Kong	3	5,000	62,800	283,000
India	5,020	285,000	3,130	228,000
Japan	479,000	11,400,000	303,000	5,330,000
Mexico	297	132,000	150	80,800
Switzerland	20	8,600	48	28,400
Taiwan	40,000	502,000	1,190	46,600
Other	465,000	4,010,000	3,350,000	7,870,000
Total	1,160,000	18,600,000	4,100,000	15,700,000
Total estimated equivalent REO content	1,390,000	18,600,000	4,920,000	15,700,000
Ferrocerium and other pyrophoric alloys (3606.90.0000):				
Argentina	13,400	74,300	29,100	162,000
Australia	73,000	167,000	19,100	984,000
Canada	667,000	2,470,000	494,000	1,620,000
China	675,000	6,050,000	169,000	1,960,000
Egypt	29,000	42,600	451	77,700
France	48,600	111,000	66,300	1,170,000
Germany	12	7,040	342	14,200
Greece	633	21,600	888	274,000
Hong Kong	19,000	439,000	26,100	306,000
Israel	29,400	48,100	75	3,230
Japan	31,700	1,240,000	17,200	461,000
Jordan	124	45,400	--	-
Korea, Republic of	4,000	131,000	4,240	255,000
Mexico	2,640,000	5,470,000	1,890,000	4,200,000
Netherlands	56,100	180,000	33,100	171,000
New Zealand	27,600	56,100	--	-
Portugal	7,820	16,600	--	-
Saudi Arabia	20	7,740	1,020	33,700
Singapore	12,000	89,300	477	14,500
Taiwan	4,710	54,200	164	5,970
United Arab Emirates	748	29,300	1,680	32,100
United Kingdom	365,000	2,840,000	296,000	14,000,000
Other	348,000	1,570,000	299,000	2,290,000
Total	5,050,000	21,200,000	3,350,000	28,000,000
Total estimated equivalent REO content	4,490,000	21,200,000	2,970,000	28,000,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the U.S. category numbers.

[3] Inorganic and organic.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF RARE EARTHS, BY COUNTRY[1]

Category[2] and country	2008 Gross weight (kilograms)	2008 Value	2009 Gross weight (kilograms)	2009 Value
Cerium compounds, including oxides, hydroxides, nitrates, sulfate, chlorides, oxalates (2846.10.0000):				
Austria	78,700	$734,000	386,000	$1,140,000
China	2,890,000	9,980,000	1,720,000	5,030,000
France	36,800	421,000	17,700	208,000
Japan	43,600	1,440,000	51,600	1,800,000
Korea, Republic of	34	21,600	--	--
United Kingdom	40,000	112,000	17,300	68,100
Other	13,200	113,000	49,200	812,000
Total	3,100,000	12,800,000	2,240,000	9,070,000
Total estimated equivalent rare-earth oxide (REO) content	2,080,000	12,800,000	1,500,000	9,070,000
Yttrium compounds content by weight greater than 19% but less than 85% oxide equivalent (2846.90.4000):				
China	8,650	202,000	8,690	136,000
France	916	61,500	945	29,800
Japan	6,860	6,490,000	1,710	362,000
Other	115	10,500	190	37,500
Total	16,500	6,770,000	11,500	565,000
Total estimated equivalent REO content	9,920	6,770,000	6,920	565,000
Rare-earth compounds, including oxides, hydroxides, nitrates, other compounds except chlorides (2846.90.8000):				
Austria	67,600	2,980,000	58,200	2,650,000
Canada	3,460	139,000	3,000	15,000
China	10,500,000	79,900,000	5,590,000	38,600,000
France	390,000	19,200,000	331,000	13,000,000
Germany	1,750	845,000	35,300	304,000
Hong Kong	234,000	2,320,000	600	5,990
Japan	234,000	10,900,000	143,000	9,350,000
Russia	96,300	470,000	109	95,300
South Africa	48,400	522,000	39,600	426,000
United Kingdom	4,030	118,000	157	49,000
Other	94,800	1,510,000	565,000	3,060,000
Total	11,600,000	119,000,000	6,770,000	67,500,000
Total estimated equivalent REO content	8,810,000	119,000,000	5,120,000	67,500,000
Mixtures of REOs except cerium oxide (2846.90.2010):				
China	2,300,000	16,000,000	4,700,000	19,100,000
Germany	450	33,300	934	108,000
Italy	56,200	6,150,000	42,500	4,190,000
Japan	1,730	312,000	6,130	64,900
Russia	1	3,800	111	66,900
United Kingdom	5	6,530	--	--
Other	32,000	56,900	--	--
Total	2,390,000	22,600,000	4,750,000	23,500,000
Total estimated equivalent REO content	2,390,000	22,600,000	4,750,000	23,500,000

See footnotes at end of table.

TABLE 5—Continued

U.S. IMPORTS FOR CONSUMPTION OF RARE EARTHS, BY COUNTRY[1]

Category[2] and country	2008		2009	
	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Rare-earth metals, whether intermixed or alloyed (2805.30.0000):				
Austria	1,570	$189,000	227	$36,100
China	540,000	3,740,000	167,000	3,790,000
Germany	5	6,750	--	--
Japan	12,600	458,000	10,800	481,000
Russia	2,690	226,000	2,110	182,000
United Kingdom	9,010	317,000	7,870	368,000
Other	--	--	81	6,450
Total	566,000	4,940,000	188,000	4,870,000
Total estimated equivalent REO content	679,000	4,940,000	226,000	4,870,000
Mixtures of rare-earth chlorides, except cerium chloride (2846.90.2050):				
China	2,580,000	16,100,000	887,000	4,560,000
Germany	5,230	203,000	129	112,000
Hong Kong	211,000	618,000	--	--
Japan	3,940	76,700	5,550	108,000
Korea, Republic of	114	10,500	--	--
Russia	38	97,100	59	127,000
Taiwan	18,000	170,000	--	--
United Kingdom	3,220	19,200	787	10,700
Other	34,300	317,000	638	12,500
Total	2,850,000	17,600,000	894,000	4,930,000
Total estimated equivalent REO content	1,310,000	17,600,000	411,000	4,930,000
Ferrocerium and other pyrophoric alloys (3606.90.3000):				
Austria	18,700	356,000	21,000	457,000
China	6,950	124,000	4,280	90,300
France	116,000	1,900,000	89,100	2,080,000
Total	141,000	2,380,000	114,000	2,620,000
Total estimated equivalent REO content	125,000	2,380,000	102,000	2,620,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the U.S. category numbers.

Source: U.S. Census Bureau.

TABLE 6
RARE EARTHS: ESTIMATED WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons of rare-earth oxide equivalent)

Country[3]	2005	2006	2007	2008	2009
Brazil	527 [4]	527 [4]	645 [4]	550	550
China	119,000	133,000	120,000	125,000	129,000
India	2,700	2,700	2,700	2,700	2,700
Kyrgyzstan:					
Compounds	NA	NA	NA	NA	NA
Metals	NA	NA	NA	NA	NA
Other	NA	NA	NA	NA	NA
Malaysia	150	430	380	233 r	25
Total	122,000	137,000	124,000	128,000 r	132,000

rRevised. NA Not available.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through October 4, 2010.

[3] In addition to the countries listed, rare-earth minerals are thought to be produced in some Commonwealth of Independent States countries besides Kyrgyzstan and in Indonesia, Nigeria, North Korea, and Vietnam, but information is inadequate for formulation of reliable estimates of output levels.

[4] Reported figure.

TABLE 7
MONAZITE CONCENTRATE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country[3]	2005	2006	2007	2008	2009
Brazil	958 [4]	958 [4]	1,173 [4]	1,200	1,200
India	5,000	5,000	5,000	5,000	5,000
Malaysia	320 [4]	894 [4]	682 [4]	700	600
Total	6,280	6,850	6,860	6,900	6,800

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 9, 2010.

[3] In addition to the countries listed, China, Indonesia, Nigeria, North Korea, the Republic of Korea, and countries of the Commonwealth of Independent States may produce monazite, available information is inadeguate for formulation of reliable estimates of ouput levels.

[4] Reported figure.

RECYCLING—METALS

By John F. Papp

Survey data and tables were prepared by Maria Arguelles, E. Lee Bray, James F. Carlin, Jr., Daniel L. Edelstein, Michael D. Fenton, Joseph Gambogi, David E. Guberman, Deborah A. Kramer, Peter H. Kuck, and Amy C. Tolcin.

In 2009, the United States recycled 58 million metric tons (Mt) of selected metals, an amount equivalent to 73% of the apparent supply of those metals (table 1). This percentage was dominated by steel because of its higher volume, and a greater percentage of steel was produced from scrap in 2009 rather than iron ore because of scrap's high availability and low cost. The United States exported 28.7 Mt of scrap metal and imported 4.4 Mt of these same metals (table 2).

Metals are important, reusable resources. Although the ultimate supply of metal is fixed by nature, human ingenuity determines the quantity of supply available for use by developing economical processes for the recovery from the Earth (the primary source of metal) and recycled from the use/process stream (the secondary source of metal). The reusable nature of metals contributes to the sustainability of their use. Recycling, a significant factor in the supply of many of the metals used by our society, provides environmental benefits such as energy savings and reduced volumes of waste.

The term "primary" indicates material from ore deposits, and the term "secondary" indicates material from recycling, including used products and residuals from manufacturing. Recycling practices and the description of those practices vary substantially among the metal industries. Generally, scrap is categorized as "new" or "old." "New" indicates preconsumer sources, and "old," postconsumer sources. The many stages of industrial processing that precede formation of an end product are the sources of new scrap. For example, when metal is converted into shapes—bars, plates, rods, or sheets—new scrap is generated in the form of cuttings, trimmings, and off-specification forms. When these shapes are converted to parts, additional new scrap may be generated in the form of cuttings, stampings, turnings, and off-specification parts. Similarly, when parts are assembled into products, new scrap may be generated.

Once a product completes its useful life, it becomes old scrap. Used appliances, automobiles, and beverage cans are examples of old consumer scrap; used jet engine blades and vanes, junked machinery and ships, and metal recovered from commercial buildings or industrial plants are examples of old industrial scrap. A wide variety of descriptive terms, including external scrap, home scrap, internal scrap, mill scrap, prompt scrap, and purchased scrap, have evolved to describe scrap generated by diverse industry practices. The material flow of recycled metal commodities in the United States has been documented in a series of reports published by the USGS (Sibley, 2004).

Individual annual reviews for each of the metals listed in the tables are in the respective chapters in this volume of the U.S. Geological Survey Minerals Yearbook, volume I, Metals and Minerals.

Reference Cited

Sibley, S.F., ed., 2006–11, Flow studies for recycling metal commodities in the United States: U.S. Geological Survey Circular 1196—A–R and T–Z, chapters are separately paged, available by searching http://pubs.er.usgs.gov/.

TABLE 1

SALIENT U.S. RECYCLING STATISTICS FOR SELECTED METALS[1]

	Quantity of metal (metric tons)					Value of metal (thousands)			
Year	Recycled from new scrap[2]	Recycled from old scrap[3]	Recycled[4]	Apparent supply[5]	Percentage recycled[6]	Recycled from new scrap[2]	Recycled from old scrap[3]	Recycled[4]	Apparent supply[7]
Aluminum:[8]									
2005	1,950,000	1,080,000	3,030,000	8,480,000 r	36 r	$3,910,000	$2,160,000	$6,070,000	$17,000,000 r
2006	2,290,000	1,260,000	3,540,000	8,190,000	43 r	6,160,000	3,380,000	9,540,000	22,000,000
2007	2,250,000	1,540,000	3,790,000	7,990,000	47	6,110,000	4,170,000	10,300,000	21,700,000
2008	1,960,000	1,370,000	3,330,000	6,900,000	48	5,240,000	3,650,000	8,890,000	18,500,000
2009	1,520,000	1,190,000	2,710,000	5,840,000	46	2,650,000	2,080,000	4,740,000	10,200,000
Chromium:[9]									
2005	NA	NA	174,000	548,000	32	NA	NA	227,000	1,530,000
2006	NA	NA	179,000	589,000	30	NA	NA	213,000	1,870,000
2007	NA	NA	162,000	493,000	33	NA	NA	297,000	1,860,000
2008	NA	NA	146,000	432,000	34	NA	NA	491,000 r	2,600,000
2009	NA	NA	141,000	160,000	88	NA	NA	185,000	233,000
Copper:[10]									
2005	769,000	183,000	953,000	3,190,000	30.0	2,940,000	701,000	3,640,000	12,200,000
2006	819,000	150,000	968,000	3,010,000	32.1	5,680,000	1,040,000	6,720,000	20,900,000
2007	767,000	158,000	925,000	3,040,000	30.5	5,550,000	1,140,000	6,690,000	22,000,000
2008	697,000	156,000 r	852,000 r	2,690,000 r	31.7 r	4,900,000	1,100,000 r	6,000,000 r	18,900,000 r
2009	638,000	137,000	774,000	2,210,000	35.0	3,390,000	727,000	4,120,000	11,800,000
Iron and steel:[11]									
2005	NA	NA	65,600,000	121,000,000	54	NA	NA	12,600,000	21,900,000
2006	NA	NA	65,300,000	137,000,000	48	NA	NA	14,300,000	28,000,000 r
2007	NA	NA	64,000,000	119,000,000	54	NA	NA	16,200,000 r	29,200,000 r
2008	NA	NA	66,400,000 r	109,000,000	62 r	NA	NA	23,200,000 r	37,600,000 r
2009	NA	NA	53,100,000	69,100,000	77	NA	NA	11,000,000	12,600,000
Lead:[12]									
2005	20,300	1,130,000	1,150,000	1,430,000	80.1	27,300	1,530,000	1,550,000	1,920,000
2006	19,600	1,140,000	1,160,000	1,470,000	78.9	33,500	1,950,000	1,980,000	2,510,000
2007	24,100	1,160,000	1,180,000	1,540,000	76.7	65,700	3,150,000	3,220,000	4,200,000
2008	20,100	1,120,000 r	1,140,000 r	1,540,000 r	74.5 r	53,300 r	2,980,000 r	3,040,000 r	4,080,000 r
2009	21,600	1,090,000	1,110,000	1,380,000	80.5	41,400	2,090,000	2,130,000	2,640,000
Magnesium:[13]									
2005	53,500	19,400	72,900	168,000	43	172,000	62,400	235,000	541,000
2006	60,500	21,700	82,200	165,000	50	155,000	55,400	210,000	421,000
2007	59,900	23,500	83,300	160,000	52	227,000	89,000	316,000	608,000
2008r	61,100	22,600	83,700	170,000	49	451,000	167,000	618,000	1,250,000
2009	47,100	19,500	66,600	116,000	57	269,000	111,000	380,000	664,000
Nickel:[14]									
2005	NA	NA	98,500	233,000 r	42	NA	NA	1,450,000	3,440,000
2006	NA	NA	103,000 r	247,000	42	NA	NA	2,510,000	5,990,000 r
2007	NA	NA	98,900 r	211,000	47	NA	NA	3,680,000	7,870,000
2008	NA	NA	85,200	200,000	43	NA	NA	1,800,000	4,230,000
2009	NA	NA	79,800	173,000	46	NA	NA	1,170,000	2,530,000
Tin:[15]									
2005	2,280	11,700	14,000	46,300	30	24,300	125,000	150,000	495,000
2006	2,340	11,600	13,900	51,600	27	29,100	145,000	174,000	642,000
2007	2,860	12,200	15,100	44,500	31	56,700	242,000	298,000	882,000
2008	2,100	11,700 r	13,800 r	24,700 r	56 r	52,300 r	291,000 r	344,000 r	615,000 r
2009	2,310	11,100	13,400	82,300	16	42,600	205,000	247,000	1,520,000

See footnotes at end of table.

TABLE 1—Continued

SALIENT U.S. RECYCLING STATISTICS FOR SELECTED METALS[1]

Year	Quantity of metal (metric tons)					Value of metal (thousands)			
	Recycled from new scrap[2]	Recycled from old scrap[3]	Recycled[4]	Apparent supply[5]	Percentage recycled[6]	Recycled from new scrap[2]	Recycled from old scrap[3]	Recycled[4]	Apparent supply[7]
Titanium:[16]									
2005	NA	NA	25,700	W	50	NA	NA	$302,000 [e]	NA
2006	NA	NA	25,000	W	47	NA	NA	253,000 [e]	NA
2007	NA	NA	23,800	W	41	NA	NA	167,000 [e]	NA
2008	NA	NA	23,200	W	W	NA	NA	148,000 [e]	NA
2009	24,700 [e]	1,000 [e]	25,700 [e]	W	W	NA	NA	101,000 [e]	NA
Zinc:[17]									
2005	303,000	50,700	354,000	1,430,000 [r]	25 [r]	$448,000	$75,000	524,000	$2,120,000 [r]
2006	294,000	47,900	342,000	1,530,000 [r]	22 [r]	1,030,000	168,000	1,200,000	5,370,000 [r]
2007	207,000	26,700	234,000	1,270,000 [r]	18 [r]	705,000	90,900	796,000	4,340,000 [r]
2008[r]	247,000	92,900	339,000	1,350,000	25	483,000	182,000	665,000	2,650,000
2009	194,000	78,800	273,000	1,170,000	23	334,000	135,000	469,000	2,000,000

[e]Estimated. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Scrap that results from the manufacturing process, including metal and alloy production. New scrap of aluminum, copper, lead, tin, and zinc excludes home scrap, which is scrap generated and recycled in the metal producing plant.

[3] Scrap that results from consumer products.

[4] Metal recovered from new plus old scrap.

[5] Apparent supply is production plus net imports plus stock changes. Production is primary production plus recycled metal. Net imports are imports minus exports. Apparent supply is calculated on a contained-weight basis.

[6] Also referred to as recycling rate.

[7] Same as apparent supply defined in footnote 5 above but calculated based on a monetary value.

[8] Quantity of metal is the calculated metallic recovery from purchased new and old aluminum-base scrap, estimated for full industry coverage. Monetary value is estimated based on average U.S. market price for primary aluminum metal ingot. Series revised by removing imported scrap to avoid double counting.

[9] Chromium quantity of metal recycled was estimated as chromium content of stainless steel scrap receipts (reported by the iron and steel and pig iron industries). For the calculation of apparent supply, trade includes reported or estimated chromium content of chromite ore, ferrochromium, chromium metal and scrap, a variety of chromium-containing chemicals, and stainless steel mill products and scrap. Stocks include estimated chromium content of reported and estimated producer, consumer, and Government stocks. Recycled monetary value estimated as recycled quantity times the average import value of high-carbon ferrochromium. Apparent supply monetary value estimated like apparent supply quantity with monetary value substituted for chromium content.

[10] Includes copper recovered from unalloyed and alloyed copper-base scrap, as refined copper or in alloy forms, as well as copper recovered from aluminum-, nickel-, and zinc-base scrap. Monetary value based on annual average refined copper prices.

[11] Recycled scrap reported from consuming manufacturers. Apparent supply measured as shipments of iron and steel products plus castings corrected for imported semifinished products. Recycled unit value is the U.S. annual average composite price for No. 1 heavy-melting steel calculated from prices published in American Metal Market. Unit value for the year used to calculate values of recycled scrap and apparent supply of scrap.

[12] Monetary value of scrap and apparent supply estimated based upon average quoted price of common lead.

[13] Includes magnesium content of aluminum-base scrap. Monetary value based on the annual average Platts Metals Week U.S. spot Western magnesium price.

[14] Nickel statistics were derived from the following:

Production, consumption, receipts

- Reported nickel content of products made from reclaimed stainless steel dust, spent nickel-cadmium batteries, plating solutions, and other products.
- Estimated nickel content of reported net receipts of alloy and stainless steel scrap.
- Reported nickel content of recovered copper-base scrap.
- Reported nickel content of obsolete and prompt purchased nickel-base scrap.
- Estimated nickel content of various types of reported obsolete and prompt aluminum scrap.

Trade data

- Reported nickel content of International Nickel Study Group (INSG) class I primary products, including briquets, cathode, flake, pellets, and powder.
- Reported or estimated nickel content of INSG class II primary products, including ferronickel, metallurgical-grade nickel oxide, and a variety of nickel-containing chemicals.
- Estimated nickel content of secondary products, including nickel waste and scrap and stainless steel scrap.

TABLE 1—Continued

SALIENT U.S. RECYCLING STATISTICS FOR SELECTED METALS[1]

Stock data

- •Reported or estimated nickel content of all scrap stocks, except copper.
- •Reported nickel content of primary products held by world producers in U.S. warehouses.
- •Reported nickel content of primary products held by U.S. consumers.
- •Reported nickel content of U.S. Government stocks.

Monetary value based on annual average cash price for cathode, as reported by the London Metal Exchange.

[15] Monetary value based on Platts Metals Week composite price for tin. Apparent supply excludes withheld stock changes.

[16] Percentage recycled based on titanium scrap consumed divided by primary sponge and scrap consumption.

[17] Monetary value based on annual average Platts Metals Week metal price for North American special high-grade zinc.

TABLE 2

SALIENT U.S. RECYCLING TRADE STATISTICS FOR SELECTED METALS[1]

	Exports			Imports for consumption		
	Quantity			Quantity		
Year	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)
Aluminum:						
2005	1,090,000	NA	$1,370,000	482,000	NA	$658,000
2006	1,480,000	NA	2,550,000	527,000	NA	930,000
2007	1,550,000	NA	3,050,000	471,000	NA	803,000
2008	1,980,000	NA	3,420,000	494,000	NA	853,000
2009	1,660,000	NA	22,100,000	433,000	NA	503,000
Chromium:[2]						
2005	585,000	99,600	675,000	111,000	19,000	124,000
2006	506,000	86,300	720,000	180,000	30,600	210,000
2007	882,000	150,000	1,620,000	118,000	20,400	200,000
2008	1,000,000	170,000	1,190,000	140,000	24,300	220,000
2009	1,130,000	192,000	778,000	124,000	21,200	138,000
Copper:[3]						
2005	658,000	556,000	1,060,000	114,000	90,300	270,000
2006	803,000	662,000	2,350,000	118,000	91,600	474,000
2007	907,000	704,000	2,840,000	133,000	112,000	665,000
2008	908,000	688,000	2,960,000	106,000	85,700	480,000 r
2009	843,000	633,000	2,010,000	71,800	56,300	234,000
Iron and steel:						
2005	13,000,000	13,000,000	3,460,000	4,000,000	4,000,000	972,000
2006	14,100,000	14,100,000	4,270,000	5,000,000	5,000,000	1,310,000
2007	16,700,000	16,700,000	6,980,000	3,780,000	3,780,000	1,080,000
2008 r	21,500,000	21,500,000	10,400,000	3,600,000	3,600,000	1,450,000
2009	22,400,000	22,400,000	7,120,000	2,990,000	2,990,000	814,000
Lead:[4]						
2005	67,300	67,300	21,600	3,840	3,340	2,880
2006	121,000	121,000	37,200	1,800	1,510	1,650
2007	129,000	129,000	55,400	1,590	1,400	2,740
2008	175,000	175,000	92,800	1,470	1,290	2,040
2009	140,000	140,000	72,000	1,600	1,310	2,620
Magnesium:						
2005	5,630	5,630	13,100	14,700	14,700	22,700
2006	3,680	3,680	8,410	17,200	17,200	23,700
2007	1,800	1,800	4,000	21,200	21,200	35,500
2008	2,600	2,600	5,420	24,100	24,100	58,800
2009	2,280	2,280	5,200	20,900	20,900	40,300

See footnotes at end of table.

TABLE 2—Continued

SALIENT U.S. RECYCLING TRADE STATISTICS FOR SELECTED METALS[1]

	Exports			Imports for consumption		
	Quantity			Quantity		
Year	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)
Nickel:[5]						
2005	2,170,000	61,900	1,190,000	550,000	17,200	304,000
2006	2,890,000	68,600	1,730,000	717,000	22,400	416,000
2007	2,800,000	110,000	3,110,000	826,000	19,000	488,000
2008	2,720,000	101,000	2,670,000	788,000	22,600	613,000
2009	2,420,000	95,100	1,710,000	699,000	20,000	442,000
Tin:						
2005	10,600	10,600	12,100	3,530	3,530	2,010
2006	7,500	7,500	14,100	2,490	2,490	4,470
2007	9,930	9,930	26,900	10,200	10,200	7,430
2008	10,300	10,300	26,600	23,300	23,300	17,700
2009	9,430	9,430	25,600	80,600	80,600	16,200
Titanium:[6]						
2005	20,600	NA	$91,400	12,400	NA	$162,000
2006	10,800	NA	110,000	12,800	NA	200,000
2007	9,510	NA	67,300	12,200	NA	133,000
2008	8,180	NA	52,000	10,400	NA	68,900
2009	4,200	NA	14,000	4,770	NA	17,600
Zinc:						
2005	46,800	NA	55,000	9,580	NA	8,820
2006	83,800	NA	95,800	14,200	NA	18,700
2007	102,000	NA	103,000	21,800	NA	32,500
2008	91,000	NA	99,100	17,000	NA	20,300
2009	47,100	NA	54,300	9,100	NA	8,800

[r] Revised. NA Not available.

[1] Contained weight based upon 100% of gross, unless otherwise specified.

[2] Includes stainless steel scrap and chromium metal waste and scrap. Contained weight for import and export quantities of Harmonized Tariff Schedule of the United States (HTS) code 7204.21.000 is 17% of gross weight; 8112.22.0000 is 100% of gross weight.

[3] For HTS codes 7404.00.0045, 7404.00.0062, and 7404.00.0080 contained weight for import quantity is 65% of gross weight. For HTS codes 7404.00.3045, 7404.00.3055, 7404.00.3065, 7404.00.3090, 7404.00.6045, 7404.00.6055, 7404.00.6065, and 7404.00.6090 contained weight for import quantity is 72%.

[4] Lead content of waste and scrap obtained from lead acid batteries (HTS 7802.00.0030) included in exports but excludes from imports.

[5] Contained weight for import and export quantities is 0.4% of gross weight for HTS code 7204.29.0000, 50% for HTS code 7503.00.0000, and 7.5% for HTS code 7204.21.0000.

[6] Includes titanium waste and scrap HTS code 8108.30.0000.

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RHENIUM

By Désirée E. Polyak

Domestic survey data and tables were prepared by Michelle B. Blackwell, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

U.S. estimated rhenium production decreased by about 29%, while apparent consumption of rhenium decreased by about 25% from that of 2008 (table 1). World production of rhenium in 2009 was estimated to be about 46,200 kilograms (kg), a 16% decrease from that of 2008 (table 4).

Production

In the United States, rhenium is a byproduct of molybdenite concentrates that are recovered as a byproduct of porphyry copper-molybdenum ore mined in the Western States. Rhenium recovery requires roasting in a facility equipped to capture the rhenium compounds in the stack gases. In the United States, only one molybdenum concentrate roasting facility is currently so equipped—the Freeport McMoRan Copper & Gold Inc. Sierrita facility in Arizona. Domestic mine production data for rhenium (table 1) were derived by the U.S. Geological Survey (USGS) from reported molybdenum production at the copper-molybdenum mines. Domestic demand for rhenium metal and other rhenium products was met by imports, from domestic recovery from ores and from stocks, and from the recycling of both spent catalysts and superalloy scrap.

Consumption

In the past decade, the two most important uses of rhenium have been in high-temperature superalloys and platinum-rhenium catalysts. Rhenium is used in single-crystal, high-temperature superalloy turbine blades for aircraft engines and other land-based turbine applications. Rhenium is used in the turbine blades closest to the combustion zone in gas turbine engines. This allows the engine to be designed with closer tolerances and allows operation at higher temperatures, which prolongs engine life and increases engine performance and operating efficiency. Platinum-rhenium catalysts are used to produce high-octane, lead-free gasoline. Other applications of rhenium, primarily as tungsten-rhenium and molybdenum-rhenium alloys, are more diverse; these included electrical contact points, flashbulbs, heating elements, metallic coatings, temperature controls, thermocouples, vacuum tubes, and x-ray tubes and targets. Industry continued to research the potential for increased recycling of rhenium-bearing turbine blades and the development of new alloys and catalysts.

World consumption of rhenium in 2009 was estimated to be about 53,500 kg, of which 78% was consumed in superalloys, 14% in catalysts, and 8% in other end uses (Roskill Information Services Ltd., 2010, p. 27). Other end uses for rhenium alloys were in crucibles, electrical contacts, electromagnets, electron tubes and targets, heating elements, ionization gauges, mass spectrographs, metallic coatings, semiconductors, temperature controls, thermocouples, and vacuum tubes.

Rhenium was used in petroleum-reforming catalysts for the production of high-octane hydrocarbons, which are used in the formulation of lead-free gasoline. Bimetallic platinum-rhenium catalysts have replaced many of the monometallic catalysts. Rhenium catalysts tolerate greater amounts of carbon formation when making gasoline, and make it possible to operate the production process at lower pressures and higher temperatures, which leads to improved yields (production per unit of catalyst used) and higher octane ratings. Platinum-rhenium catalysts also were used in the production of benzene, toluene, and xylenes, although this use was small compared with that used in gasoline production.

General Electric Aviation (GE), a subsidiary of General Electric Company (Fairfield, CT), announced that it had developed two new alloys as part of the company's overall strategy to conserve and recycle rhenium. The first new alloy, the N500, a rhenium-free alloy, was expected to be used in stationary parts such as engine nozzles and shrouds. The second new alloy, René N515, used less rhenium (1.5%) while providing the properties of other second-generation alloys that used significantly more rhenium (3%). According to the company, René N515 has been tested extensively and has been introduced into the CFM56 turbine blades in jet engines. Computer modeling enabled the development and introduction of the alloy in 2 years compared with the traditional developmental time of 4 years (Fink and others, 2010). However, it was important to note that René N515 has been described as having an oxidation resistance capability at 1,175° C. This temperature was not expected to be an operating temperature that could power many of the larger jet engines that run at higher temperatures. The only alloys capable of running at these extreme temperatures were the current second-generation (3% Re) and third-generation (6% Re) alloys, making GE's new alloys inadequate for larger jet engines (Lipmann Walton & Co. Ltd., 2010).

GE also continued to recycle used, high-pressure turbine blades (HPTBs) made of a rhenium-bearing nickel superalloy that was cleaned and melted for reuse in manufacturing new HPTBs. Although the lifespan of engine parts was variable, a turbine blade was expected to last approximately 10 years. According to the company, more than 10% of their rhenium came from recycling, and they expected the percentage to increase in 2010 (Metal-Pages, 2009b).

Construction of Kennecott Utah Copper's molybdenum autoclave process (MAP) facility, approved during the second quarter of 2008, continued to be delayed owing to decreased molybdenum prices. The MAP was expected to enable lower grade concentrate to be processed more efficiently than in conventional roasters, allow improved molybdenum recovery, and enable production of chemical-grade molybdenum products

(Rio Tinto plc, 2010, p. 40). The new facility would have the capacity to recover approximately 3 to 5 metric tons per year (t/yr) of rhenium. Unlike the roasting process, the autoclave system would extract rhenium at the crystallization stage, and recover it, as in the old roasting process, via ion exchange. The final products would be high-purity ammonium perrhenate (APR) suitable for catalysts and rhenium metal for the aerospace industry. The facility was expected to be completed in the fourth quarter of 2011 and was expected to reach full capacity in 2012 (Metal-Pages, 2009a.)

Prices

Rhenium metal powder and APR average annual prices were estimated to be about $6,700 per kilogram and $7,800 per kilogram of rhenium content, respectively. The powder price was about $9,000 per kilogram in January, before it began its decline to $6,500 per kilogram in May. The powder price remained steady at nearly $6,500 per kilogram until August when it reached its yearly low of $4,800 per kilogram. The powder price increased slightly to close the year at about $5,200 per kilogram in December. The APR price was about $10,000 per kilogram in January and February before it began its decline in March to $9,600 per kilogram. The APR price continued a gradual decrease to $6,800 per kilogram in June and stayed at approximately $6,300 per kilogram for the remainder of the year.

Foreign Trade

Compared with those of 2008, imports of rhenium metal decreased by about 40% (table 2) owing to weaker U.S. demand, while imports of APR increased by about 28% (table 3). Chile and Germany were the leading suppliers of rhenium metal to the United States; Chile, Mongolia, Poland, and the United Kingdom were the leading suppliers of APR. Imports for consumption of rhenium metal are shown in tables 1 and 2, and those of APR are shown in tables 1 and 3.

World Review

World production of rhenium was estimated to have been about 46,200 kg in 2009 (table 4). This estimate was based on the quantity of rhenium recovered from concentrates that were processed to recover rhenium values.

Rhenium was recovered as a byproduct from porphyry copper-molybdenum ores mined primarily in Canada, Chile, Mexico, Peru, Poland, and the United States. Rhenium is also associated with copper minerals in sedimentary deposits in Armenia, Kazakhstan, Russia, and Uzbekistan, where ore is processed for copper recovery and the rhenium-bearing residues are recovered at the copper smelter. Rhenium-bearing residues from both sources are processed for recovery either as APR for catalyst uses, or as a metal powder for superalloys. The major producers of rhenium metal and compounds were Chile, Germany, the Netherlands, the United Kingdom, and the United States.

World reserves of rhenium are contained primarily in molybdenite in porphyry copper deposits. U.S. reserves of rhenium are concentrated in Arizona, Montana, Nevada, New Mexico, and Utah. Chilean reserves are found primarily at four large porphyry copper deposits and in lesser deposits in the northern half of the country. In Peru, reserves are concentrated primarily in the Toquepala open pit porphyry copper mine and in about 12 other deposits. Other world reserves are contained in several porphyry copper deposits and sedimentary copper deposits in Armenia, northwestern China, Iran, Kazakhstan, Russia, and Uzbekistan, and in sedimentary copper-cobalt deposits in Congo (Kinshasa). U.S. reserves were estimated to be about 390 t, and rest-of-the-world reserves were estimated to be about 2,100 t.

Australia.—Ivanhoe Australia Ltd. (Melbourne) announced that further test drilling, near its Merlin site in northwestern Queensland, revealed an additional high-grade source of molybdenum and rhenium. The new site was expected to be named the Little Wizard project. According to the company, the Merlin project was the highest grade source of molybdenum and rhenium identified anywhere in the world. An initial mineral resource estimate revealed potential for approximately 91,000 t of contained molybdenum and 152,000 kg of rhenium. In 2010, the company expected to begin a prefeasibility study to develop the Merlin deposit. Environmental permitting would be undertaken in parallel with the prefeasibility study and was expected to be completed by November 2010 (Ivanhoe Australia Ltd., 2009, 2010.)

Canada.—In December, MetalCORP Ltd. (Toronto, Ontario) announced the results of the first mineral resource estimate for its Playter molybdenum-rhenium deposit in eastern Ontario, prepared by AMEC Americas Ltd. Inferred resources were estimated to be 874,410 t grading 0.25% molybdenum and 1.67 grams per metric ton of rhenium. AMEC was unable to make an estimate for some of the mineralization owing to lack of verified data and recommended further drilling. According to MetalCORP, the resource estimate showed higher-than-expected metal grade but a lower-than-expected tonnage, and the company was uncertain if further exploration was advisable (MetalCORP Ltd., 2009).

Chile.—Molibdenos y Metales S.A. (Molymet) (Santiago) maintained roasting facilities equipped for rhenium recovery in Belgium, Chile, and Mexico. Molymet primarily toll roasted byproduct molybdenum concentrates for Corporación Nacional del Cobre de Chile (Codelco), but also sourced concentrates from Canada, Mexico, Peru, and the United States. Codelco and Xstrata plc. also roasted byproduct molybdenum concentrates in Chile, but those roasters were not currently equipped for rhenium recovery. In December 2008, Molymet stopped fundraising to finance a new $120 million molybdenum smelter near Mejillones in Chile.

In December, Codelco announced that it had requested approval from the regional environment commission to refurbish and restart operations of the rhenium recovery plant at its Chuquicamata site at a cost of $4.5 million. The plant was expected to produce 2.1 t of rhenium metal briquettes in 2010, increasing to 2.8 t/yr in 2011. The rhenium recovery plant was built in 1990 and began production in 1991, but operations were halted in 1996 after rhenium market conditions deteriorated (Platts Metals Week, 2009).

Kazakhstan.—Zhezkazganredmet (Redmet), Kazakhstan's state-owned rhenium producer, received rhenium-bearing residues from the Dzhezkazgan Copper Works mine and smelter complex in Kazakhstan. Dzhezkazgan was controlled by Kazakh Copper, and its parent Samsung Corp., which received 50% of Redmet's production as payment for the rhenium residues. A disagreement, beginning in 2007, between Kazak Copper and Redmet resulted in rhenium production slipping from 8 t in 2006 to an estimated 3 t in 2009. The Dzhezkazgan plant was also expected to undergo refurbishment in 2010, which was expected to further decrease rhenium production (Kazakhmys plc, 2010).

Poland.—KGHM Ecoren S.A. (Lubin) announced that the construction of the technological line for rhenium metal recovery from APR at the Legnica Technological Park LETIA was expected to be completed by early 2010. According to the company, the Glogów copper mill in southwestern Poland has Europe's only facility for recovering rhenium from industrial waste. The project was launched in September 2007 on the basis of a rhenium recovery method developed by KGHM and the Institute of Non-Ferrous Metals in Gilwice, Poland. The innovative rhenium recovery technology used is based on recycling acid effluents, with the recovery of the APR from acid solutions containing the metal. In 2009, production of APR decreased to 3.5 t from 4.9 t in 2008 (KGHM Ecoren S.A., 2009). Poland's rhenium production is mostly committed on long-term contracts to British customers Rolls-Royce Group plc and Johnson Matthey plc (Metal-Pages, 2009b).

Outlook

The global economic downturn, particularly in North America and Europe, severely affected the major markets for rhenium and world rhenium demand dropped by 16% in 2009. In 2010, rhenium demand is expected to recover. The United States is the world's largest producer of aerospace superalloys and is, therefore, the largest consumer of rhenium (Roskill Information Services Ltd., 2010, p. 34). With the top three consumers alone—GE, Pratt & Whitney, and Cannon Muskegon Corp.—consuming an estimated 45 t/yr of rhenium, more developments like Poland's new rhenium facility are needed.

As the life cycle of turbine blades in jet engines is approximately 10 years, significant quantities of second-generation blades (3% Re) are accumulating.Technology is beginning to be developed to allow recycling of second-generation blades for recovery of rhenium that can be used in the manufacture of new third-generation blades, potentially reducing requirements for virgin rhenium by about 50%. The majority of rhenium recycling is currently performed in Germany and the United States, but significant amounts are also being recovered in Estonia and Russia.

Potential molybdenum producers continued to look at ways to increase the value of future production since the collapse in the molybdenum price. For some, producing byproduct rhenium is a strong possibility. Perhaps the greatest potential for increased rhenium production lies in the molybdenum concentrates that are presently being roasted in facilities that are not equipped to recover the rhenium values. For example, Rio Tinto's new MAP facility would allow Rio Tinto to recover approximately 3 to 5 t/yr of rhenium, potentially increasing U.S. rhenium production by more than 50%.

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TABLE 1

SALIENT U.S. RHENIUM STATISTICS[1]

(Kilograms, gross weight)

	2005	2006	2007	2008	2009
Production[2]	7,900	8,100	7,100 [r]	7,900 [r]	5,600
Apparent consumption[e, 3]	30,200 [r]	40,200 [r]	38,800 [r]	40,600 [r]	30,500
Imports:					
Metal	21,800	22,000	30,500	35,900	21,500
Ammonium perrhenate	10,300	24,300	15,100	11,200 [r]	14,300

[e] Estimated. [r] Revised.

[1] Data are rounded to no more than three significant digits.

[2] Rhenium contained in molybdenite concentrates, based on calculations by the U.S. Geological Survey. Data rounded to two significant digits.

[3] Calculated as production plus imports minus exports and industry stock changes.

TABLE 2

U.S. IMPORTS FOR CONSUMPTION OF RHENIUM METAL, BY COUNTRY[1]

	2008		2009	
Country	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
Belgium	157	$192	--	--
Canada	--	--	39	$73
Chile	28,500	55,800	20,100	47,200
China	12	60	--	--
France	419	673	--	--
Germany	1,640	7,090	1,030	3,820
Guadeloupe	1	4	--	--
Japan	13	38	--	--
Netherlands	5,060	8,450	219	1,940
United Kingdom	130	462	119	61
Total	35,900	72,800	21,500	53,100

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF AMMONIUM PERRHENATE, BY COUNTRY[1]

	2008		2009	
Country	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
Belgium	162	$4	--	--
Chile	246	776 [r]	4,800	$361
China	1,350	6,080 [r]	--	--
Germany	214	1,220	--	--
Kazakhstan	8,890	15,100	--	--
Korea, Republic of	4	13 [r]	--	--
Mongolia	238	753 [r]	2,390	180
Netherlands	--	--	1	4
Poland	--	--	1,870	698
Russia	100	314	--	--
United Kingdom	2	6	5,260	12,400
Total	11,200 [r]	24,200	14,300	13,700

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 4
RHENIUM: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Kilograms)

Country	2005	2006	2007	2008	2009
Armenia	1,200	1,200	400 [r]	400 [r]	400
Canada	1,300	1,200	1,200	1,600	1,800
Chile[3]	21,500 [r]	19,800	22,900	27,600	25,000
Kazakhstan	8,000	8,000	5,500 [r]	5,500 [r]	3,000
Peru	5,000	5,000	5,000	5,000	5,000
Poland[4]	--	1,040 [5]	2,420 [5]	3,390 [5]	2,420 [5]
Russia	1,400	1,400	1,500	1,500	1,500
United States[4, 6]	7,900	8,100	7,100	7,900	5,600
Uzbekistan	NA	NA	NA	NA	NA
Other	1,000	1,000 [r]	1,500 [r]	2,000 [r]	1,500
Total	47,300 [r]	46,700 [r]	47,500 [r]	54,900 [r]	46,200

[r] Revised. NA Not available. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 27, 2010.

[3] Data revised based on new information from Comisión Chilena del Cobre; also includes rhenium content from Mexico processed at Molymet in Chile.

[4] Reported figure.

[5] Data based on new information from KGHM Ecoren S.A. Calculated based on 69.2% rhenium content of ammonium perrhenate.

[6] Calculated rhenium contained in molybdenite concentrates. Data rounded to two significant digits.

SALT

By Dennis S. Kostick

Domestic survey data and tables were prepared by Martha L. Jackson, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

The United States had been the world's leading salt producing nation until 2005, when China surpassed the United States to become the leading producing country in the world. Total U.S. salt production in 2009 decreased by 4% to 46 million metric tons (Mt) compared with that of 2008 (table 1). According to U.S. Geological Survey (USGS) data for 2009, 27 companies operated 60 salt-producing plants in 16 States. Of these, 10 companies and 14 plants produced more than 1 Mt each and accounted for 92% and 69%, respectively, of total U.S. production and accounted for 89% and 44%, respectively, of total value. Several companies and plants produced more than one type of salt. In 2009, 11 companies (25 operations) produced salt brine; 11 companies (15 operations), rock salt; 10 companies (13 operations), solar-evaporated salt; and 7 companies (17 operations), vacuum pan salt.

The five leading States were, in descending order of total salt sold or used, Louisiana with 31%; Texas, 21%; New York, 14%; Kansas, 6%; and Utah, 5%. Other Eastern States (Alabama, Michigan, Ohio, Tennessee, Virginia, and West Virginia) accounted for 20% of the domestic total salt sold or used. Other Western States (Arizona, California, Nevada, New Mexico, and Oklahoma) represented 3% (table 5).

Salt, also known as sodium chloride, comprises the elements sodium and chlorine. Sodium is a silver-colored metal that is so unstable that it reacts violently in the presence of water; chlorine is a greenish-colored gas that is dangerous and may be lethal. Yet combined, these two elements form sodium chloride, which is a white-colored compound essential to life itself. Virtually every person in the world has some direct or indirect contact with salt daily. People routinely add salt to their food as a flavor enhancer or apply rock salt to walkways to remove ice in the winter. Salt is used as feedstock for chlorine and caustic soda manufacture. These two inorganic chemicals are used to make many consumer-related end-use products, such as polyvinyl chloride (PVC), a plastic made from chlorine, and paper-pulping chemicals manufactured from sodium hydroxide (caustic soda).

Production

U.S. production and sales data for salt are developed by the USGS from an annual voluntary survey of U.S. salt-producing sites and company operations (table 2). Production refers to the quantity of salt mined or manufactured that is available for sale. Salt sold or used is the quantity of salt that was sold directly to customers or used by the salt producer, which usually is a chloralkali (chlorine and sodium hydroxide) manufacturer. The data in table 2 are rated capacities for mines and refineries as of December 31, 2009. Rated capacity is defined as the maximum quantity of product that can be produced in a period of time on a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving energy, labor, maintenance, and materials.

Of the 27 companies to which a canvass form was sent, 26 responded, representing 91% of the totals shown in this report. Data for the nonrespondent was estimated based on its prior responses to previous annual surveys, the 2009 production estimate survey, or brine production capabilities for chloralkali manufacture based upon published chlorine production capacities [1.75 metric tons (t) of salt required per ton of chlorine capacity].

The structure of the U.S. salt industry has changed throughout the years. In 1970, 50 companies operated 95 salt-producing plants in the United States. Market competition, increased energy and labor costs, less expensive imports, fluctuations in currency exchange rates, and an excess of production capacity (resulting in the downsizing of the industry through mergers and acquisitions) reduced the number of operations in the industry to 27 companies and 60 plants by 2009.

The four types of salt that are surveyed are classified according to the method of recovery as follows: rock salt, from the surface or underground mining of halite deposits; solar salt, from the solar evaporation of seawater, landlocked bodies of saline water, or primary or byproduct brines; vacuum pan salt, from the mechanical evaporation of a purified brine feedstock; and brine, from the solution mining of underground halite deposits. Data for brine production and consumption represent the anhydrous salt content only and not the weight of the water.

Mechanical Evaporation.—Vacuum pan salt is not mined but is a type of salt produced using mechanical evaporation technology. Vacuum pan salt production was 4.03 Mt in 2009, which was a 4% decrease compared with the 2008 revised total of 4.20 Mt. The mechanical evaporation of salt by the vacuum pan process is dependent on the number and size of the vacuum crystallizers operating in series. Rated capacities in table 2 are usually easier to establish because of the proven design performance of the equipment.

Although rock salt, solar salt, and salt brine may be used to make vacuum pan salt, virtually all domestic vacuum pan salt is obtained from solution mining of underground salt formations. Vacuum pan salt is obtained by dehydrating brine using heat alone or in combination with a vacuum. The grainer or open pan process uses open, rectangular pans with steam-heated immersion coils to evaporate the water in the brine. The final product is usually flake shaped rather than the typical cubic form. Flake salt is preferred for the production of baked goods, butter, and cheese. The Alberger process is a modified grainer operation that produces cubic salt with some flake salt.

In July 2008, the Dow Chemical Co. purchased Rohm and Haas Co. of Philadelphia, PA, for $18 billion. The sale included Morton International Inc., with its salt subsidiary Morton Salt

Co. In September 2009, with the approval of the U.S. Federal Trade Commission, Dow sold off the salt business to K+S Aktiengesellschaft (formerly Kali und Salz GmbH) of Germany, establishing K+S as the leading salt producer in the world. The net cash payment for the acquisition was $1.576 billion (CBS Interactive Business Network, 2009; K+S Group, 2009).

Rock Salt.—Rock salt is mined by the room-and-pillar method, which is similar to that used in coal and trona mining. Additional information about rock salt mining can be found in the salt chapter in Minerals Yearbook 2006.

Because the majority of rock salt was used for deicing, the operating rate of rock salt facilities fluctuated with the demand for deicing salt, again dependent on the severity of winter weather conditions. During periods of strong demand, production levels often achieve, or exceed in certain situations, the rated capacities. Full mine capacity generally is a function of the hoisting capabilities of the mine. Assuming that the work week is 5 days (250 workdays per year), two working shifts and one maintenance shift per day, and at least one short-term planned turnaround for the mine and mill per year, table 2 lists the production capacities for domestic rock salt operations. In 2009, rock salt mining was 20.3 Mt, a 3% decrease compared with the 2008 revised total of 20.9 Mt.

Solar Evaporation.—Solar salt production was 3.88 Mt in 2009, which was a 5% decrease from the revised 2008 total of 4.07 Mt. Solar evaporation uses the wind and the sun to evaporate the water and is an effective method of producing solar salt in areas of high evaporation and low precipitation. Additional information about solar salt production can be found in the 2006 salt Minerals Yearbook chapter.

Because evaporation rates must exceed the precipitation rates, the climatic conditions and geographic locations of solar evaporation facilities are critical to the successful production and harvesting of solar salt. Therefore, rated capacities in table 2 generally are based on the historical evaporation patterns within a region and vary depending on the location and the surface acres of the evaporation ponds. Only unpredictable seasonal precipitation and market conditions usually affect the production rates of the facilities.

Solution Mining.—U.S. salt brine production in 2009 was 17.8 Mt, which was about 6% less than the 2008 total of 18.9 Mt. This was the second consecutive year that total brine production did not exceed rock salt production. The brine capacities for table 2 are difficult to derive because they are based on the variabilities of the injection rate of the solvent and the solubility rates of the underground salt bodies, both of which determine the quantity of brine produced. In turn, these production levels are usually dependent on the demand for the products that the brine is being used to manufacture. Brine capacity is assumed to be equal to the amount of annual brine production. In order to avoid revealing company proprietary data, individual company brine capacities are not included in table 2.

Solution mining is used to obtain a sodium chloride feedstock for vacuum pan salt production and for chlorine, caustic soda, and synthetic soda ash (excluding the United States) manufacture. The quantity of underground salt dissolved and recovered as brine to make vacuum pan salt usually is not reported as primary salt production; only the quantity of vacuum pan salt manufactured is reported. The quantity of brine used to make chloralkali chemicals is reported as either the amount of captive brine used or brine sold. The chemical industry is the leading consumer of salt brine worldwide. Additional information about salt brine production can be found in the 2006 salt Minerals Yearbook chapter.

Consumption

In 2009, apparent consumption (salt sold or used plus imports minus exports) was 56.4 Mt, whereas reported consumption (sales or use as reported by the salt companies, including their imports and exports) was 45 Mt. Although these two measures of consumption are not necessarily expected to be identical, they normally are similar. Apparent consumption normally is greater than reported consumption because apparent consumption includes additional quantities of salt imported and exported by nonsalt-producing companies, such as some chloralkali operations and salt distributors. Reported consumption statistics are those reported only by the domestic salt producing companies.

The direct and indirect uses of salt number about 14,000 according to industry sources. The USGS annually surveys eight major categories comprising 29 end uses. The 2009 reported percentage distribution of salt by major end use was chemicals, 40%; ice control, 38%; distributors (grocery and other wholesalers and retailers, and so forth), 8%; agricultural and food processing, 4% each; and general industrial, other uses combined with exports, and primary water treatment, 2% each; (table 6). Distributors represented a substantial share of salt sales by the salt industry; all this salt is ultimately resold to many different end users. For a more complete analysis of end-use markets, specific sectors of distribution in table 6 can be combined, such as agricultural and water treatment with agricultural and water conditioning distribution, respectively.

Aside from the different types of salt, there are various distinctions in the packaging and applications of salt. Salt for human consumption is packaged in different sized containers for several specialized purposes. Table salt may contain 0.01% potassium iodide as an additive, which provides a source of iodine that is essential to the oxidation processes in the body. Kosher salt, sea salt, condiment salt, and salt tablets are special varieties of salt.

Agricultural Industry.—Barnyard and grazing livestock need supplementary salt rations to maintain proper nutrition. In 2009, 1.21 Mt of salt was sold to the agricultural industry. Animal feed and water conditioning salt are made into 22.7-kilogram (50-pound) pressed blocks. Iodine, sulfur, trace elements, and vitamins are occasionally added to salt blocks to provide nutrients not found naturally in the diet of certain livestock. Salt is also compressed into pellets that are used for water conditioning.

Chemical Industry.—For most years, the leading consumer of salt, primarily as salt brine, is the chemical industry. Salt brine is extracted from natural underground saline sources or solution-mined halite deposits (salt beds or salt domes) or produced through the dissolution of solar salt. Within this industry, the chloralkali sector remains the major consumer of salt for manufacturing chlorine, coproduct sodium hydroxide (caustic soda), and synthetic soda ash. Since 1986, when the last domestic synthetic soda ash plant was closed because of high production costs and competition with less expensive natural soda ash, no synthetic soda ash has been manufactured in the United States; many countries, however, still produce synthetic soda ash and use vast quantities of salt brine as feedstock. Total salt sold or used by the chemical industry was 17.9 Mt, in 2009 of which 16.7 Mt was for chloralkali manufacture and 1.24 Mt was for other chemical uses (table 6).

Salt is used as the primary raw material in chlorine manufacture because it is an inexpensive and widely available source of chlorine ions. For sodium hydroxide production, salt is the main source of sodium ions. Chlorine and caustic soda are considered to be the first generation of products made from salt. These two chemicals are further used to manufacture other materials, which are considered to be the second generation of products made from salt. Although most salt brine is produced by the same companies that use it, many chloralkali manufacturers now purchase brine from independent brine supply companies. In certain cases, brine is produced by a chemical company that uses some of it and sells the excess to neighboring competitors. According to industry sources, about 48% of the salt used to manufacture chlorine was captive (produced by the chloralkali companies) and 31% was purchased brine; domestically purchased solar salt and rock salt made up 12% of the supply, and imported rock, solar, and vacuum pan salt, 9%.

In 2009, according to the U.S. Census Bureau, 8.52 Mt of chlorine and 6.57 Mt of sodium hydroxide (caustic soda or lye) were produced in the United States (U.S. Census Bureau, 2010). Based on the industry average ratio of 1.75 t of salt required to produce 1.0 t of chlorine and 1.1 t of coproduct sodium hydroxide, the chlorine and caustic soda industry consumed about 14.9 Mt of salt for feedstock. Reported consumption of total domestic and imported salt for chlorine manufacture was 16.7 Mt (table 6). Typically, the difference between the calculated and reported quantities was the amount of salt not reported to the USGS from imports or captive brine production of chloralkali producers, although in 2009, the difference was about 2 Mt. This difference may be because of unreported chlorine production data.

Salt is also used as a feedstock in chemical plants that make sodium chlorate, metallic sodium, and other downstream chemical products. In powdered soaps and detergents, salt is used as a bulking agent and a coagulant for colloidal dispersion after saponification. In pharmaceuticals, salt is a chemical reagent and is used as the electrolyte in saline solutions. It is used with sulfuric acid to produce sodium sulfate and hydrochloric acid. The "Other chemical" subsector is relatively small, representing about 7% of domestic salt sales for the entire chemical sector and only 3% of total domestic salt consumption.

The consumption of salt for metallic sodium has declined during the past several years. E.I. du Pont de Nemours and Co. was the sole manufacturer of metallic sodium in the United States. The domestic market for metallic sodium decreased because sodium metal was no longer needed for the production of leaded gasoline. The leading use of sodium was for sodium borohydride production, which is the feedstock for sodium dithionite that is used as a reductive bleaching agent by the pulp and paper industry. Sodium metal also is used to manufacture sodium azide, which is used in automotive air bags. Other potential uses of sodium metal are in the remediation of chemical weapons, chlorofluorocarbons, pesticides, and polychlorinated biphenyls.

Distributors.—A large amount of salt is marketed through various distributors, some of which specialize in agricultural and water treatment services—two sectors in which the salt companies also have direct sales (table 6). Distributor sales also include grocery wholesalers and (or) retailers, institutional wholesalers, U.S. Government resale, and other wholesalers and retailers. Total salt sold to distributors was 3.91 Mt in 2009.

Food Processing.—Every person uses some quantity of salt in food. The salt is added to the food by the food processor or by the consumer as a flavor enhancer, preservative, binder, fermentation-control additive, texture-control agent, and color developer. This major category is subdivided, in descending order of salt consumption, into other food processing, meat packers, canning, baking, dairy, and grain mill products. Total salt sold for food processing was 1.72 Mt in 2009.

In meat packing, salt is added to processed meats to promote color development in bacon, ham, and other processed meat products. As a preservative, salt inhibits the growth of bacteria, which would lead to spoilage of the product. Salt acts as a binder in sausages to form a binding gel made up of meat, fat, and moisture. Salt also acts as a flavor enhancer and as a tenderizer.

In the dairy industry, salt is added to cheese as a color-, fermentation-, and texture-control agent. The dairy subsector includes companies that manufacture creamery butter, condensed and evaporated milk, frozen desserts, ice cream, natural and processed cheese, and specialty dairy products.

In canning, salt is primarily added as a flavor enhancer and preservative. It also is used as a carrier for other ingredients, dehydrating agent, enzyme inhibitor, and tenderizer.

In baking, salt is added to control the rate of fermentation in bread dough. It also is used to strengthen the gluten (the elastic protein-water complex in certain doughs) and as a flavor enhancer, such as a topping on baked goods.

The food-processing category also contains grain mill products. These products consist of milling flour and rice and manufacturing cereal breakfast food and blended or prepared flour.

In the "other food processing" category, salt is used mainly as a seasoning agent. This category includes miscellaneous establishments that make food for human consumption (such as potato chips and pretzels) and for domestic pet consumption (such as cat and dog food).

General Industrial.—The industrial uses of salt are diverse. They include, in descending order of quantity consumed, other industrial applications, oil and gas exploration, textiles and dyeing, pulp and paper, metal processing, tanning and leather treatment, and rubber manufacture. Total salt sold to these sectors was 792,000 t in 2009.

In oil and gas exploration, salt is an important component of drilling fluids in well drilling. It is used to flocculate and increase the density of the drilling fluid to overcome high downwell gas pressures. Whenever a drill hits a salt formation, salt is added to the drilling fluid to saturate the solution and to minimize the dissolution within the salt stratum. Salt is also used to increase the set rate of concrete in cemented casings.

In textiles and dyeing, salt is used as a brine rinse to separate organic contaminants, to promote "salting out" of dyestuff precipitates, and to blend with concentrated dyes to standardize them. One of its main roles is to provide the positive ion charge to promote the absorption of negatively charged ions of dyes.

In metal processing, salt is used in concentrating uranium ore into uranium oxide (yellow cake). It also is used in processing aluminum, beryllium, copper, steel, and vanadium.

In the pulp and paper industry, salt is used to bleach wood pulp. It also is used to make sodium chlorate, which is added along with sulfuric acid and water to manufacture chlorine dioxide, an excellent oxygen-based bleaching chemical. The chlorine dioxide process, which originated in Germany after World War I, is becoming more popular because of environmental pressures to reduce or eliminate chlorinated bleaching compounds.

In tanning and leather treatment, salt is added to animal hides to inhibit microbial activity on the underside of the hides and to attract moisture back into the hides. In rubber manufacture, salt is used to make buna, neoprene, and white types. Salt brine and sulfuric acid are used to coagulate an emulsified latex made from chlorinated butadiene.

Ice Control and Road Stabilization.—In 2009, U.S. consumption of salt for this application was 16.9 Mt, which was about 25% less than that of 2008. This decrease was attributed to the reduction of municipal inventories from those of 2008. Additional imports of rock salt by the salt companies were available if needed during 2009.

Salt is an inexpensive, widely available, and effective ice control agent. It does, however, become less effective as the temperature decreases below about 6.5° C to 9.5° C (15° F to 20° F). At lower temperatures, more salt must be applied to maintain higher brine concentrations to provide the same degree of melting. Most winter snowstorms and ice storms happen when temperatures are between 4° C and 0° C (25° F and 32° F), the range in which salt is most effective.

In highway deicing, salt has been associated with corrosion of bridge decks, motor vehicles, reinforcement bar and wire, and unprotected steel structures used in road construction. Surface runoff, vehicle spraying, and windblown actions also affect soil, roadside vegetation, and local surface water and groundwater supplies. Although evidence of environmental loading of salt has been found during peak usage, the spring rains and thaws usually dilute the concentrations of sodium in the area where salt was applied.

The quantity of salt consumed for road deicing each year is directly related to the severity of the winter weather conditions. Long-range forecasting of salt consumption in this application is extremely difficult because of the complexities in long-range forecasting of the weather.

Salt also is added to stabilize the soil and to provide firmness to the foundation on which highways are built. The salt acts to minimize the effects of shifting caused in the subsurface by changes in humidity and traffic load.

During the winter of 2008–09, many municipalities across the nation reported apparent shortages of rock salt and significant increases in rock salt prices compared with those of the previous winter. In late 2009, the situation had reversed itself when supplies became more available at lower prices (WFMJ, 2009).

Questions raised in 2008 regarding the shortage of salt and the high prices of rock salt concerned several State government officials, who were skeptical and initiated various investigations of potential price-fixing by suppliers. One extensive investigation by the office of the Illinois Attorney General found no evidence of price fixing or illegal conduct by the road salt suppliers but rather procedural problems with their procurement process (Hilkevitch, 2009). Many municipalities waited until the summer months to solicit bids from the salt suppliers for the upcoming winter. As a result, some municipalities found themselves without any salt because other transportation departments had submitted their requests earlier so the salt companies could have the necessary time to schedule production and delivery times. For 2009, many State and local agencies sought bids as early as March to guarantee their requests would be received in plenty of time for the next winter (Farkas, 2009).

Water Treatment.—Many areas of the United States have hard water, which contains excessive calcium and magnesium ions that contribute to the buildup of a scale or film of alkaline mineral deposits in household and industrial equipment and pipes. Commercial and residential water-softening units use salt to remove the ions that cause the hardness. The sodium ions captured on a resin bed are exchanged for the calcium and magnesium ions. Periodically, the water-softening units must be recharged because the sodium ions become depleted. Salt is added and dissolved, and brine replenishes the lost sodium ions. In 2009, 1.01 Mt of salt was sold for primary water treatment and an additional 469,000 t was sold for water conditioning distribution.

Stocks

Because bulk salt is stored at many different locations, such as plants, ports, terminals, and warehouses, data on the quantity of salt stockpiled by the salt industry are not reliable enough to formulate accurate inventory totals; however, yearend stocks of producers were estimated to be 2 Mt, and consumer inventories also were estimated to be high. Most of these inventories were imported rock salt and solar salt. Many salt distributors, municipalities, road deicing contractors, salt producers, and States stockpiled additional quantities of salt in anticipation of adverse weather conditions. Deicing salt inventories were reduced by yearend 2009 because of moderately severe winter weather during late 2009. For the reasons discussed above, salt stocks are assumed to be the difference between salt production and salt sold or used in calculating apparent consumption.

Transportation

Because the locations of the salt supplies are not often near consumers, transportation may be an important cost. Pumping salt brine through pipelines is an economic means of transportation but cannot be used for dry salt. Large bulk shipments of dry salt in ocean freighters or river barges are low in cost but are restricted in points of origin and consumption. River and lake movement of salt in winter is often severely curtailed because of frozen waterways. As salt is packaged, handled, and shipped in smaller units, the costs increase and are reflected in higher selling prices.

Transportation costs significantly add to the price of salt. In some cases, shipping costs are higher than the actual value of the salt. Ocean vessels can transport greater quantities of salt than barge, rail, or truck shipments. Transoceanic imports of salt have been increasing in some areas of the United States because they are more cost competitive than salt purchased from domestic suppliers using barge, rail, or truck transportation. One important factor that often determines the quantity of salt that can be imported is the depth of the channels and the ports; many ports are not deep enough to accommodate larger ships.

Prices

The four types of salt that are produced have unique production, processing, and packaging factors that determine the selling prices. Generally, salt sold in bulk is less expensive than salt that has been packaged, pelletized, or pressed into blocks. Salt in brine is the least expensive salt sold because mining and processing costs are less. Vacuum pan salt is the most expensive because of the higher energy costs involved in processing and the purity of the product.

Price quotations are not synonymous with average values reported to the USGS. The quotations do not necessarily represent prices at which transactions actually took place or bid and asked prices. The average annual values, as collected by the USGS and listed in table 8, represent a national average value for each of the types of salt and the various product forms.

Foreign Trade

Under Harmonized Tariff Schedule of the United States (HTS) nomenclature, imports are aggregated under one category named "Salt (including table and denatured salt) and pure sodium chloride, whether or not in aqueous solution, seawater." The same classification also applies to exports. The HTS code for salt is 2501.00.0000. The trade tables in this report list the previous and current identification codes for salt. Although several other HTS codes pertain to various salt classifications, the United States aggregates shipments under one code because the sums of individual subclassifications fail to meet the minimum dollar requirements necessary for individual listings.

Based on U.S. Census Bureau data for 2009, the United States exported 1.45 Mt of salt; this was a 40% increase compared with that of 2008 (table 9). In 2009, the majority of exports (94%) were to Canada. Salt was shipped to 86 countries through 21 customs districts; the Detroit, MI, district exported the most and represented 83% of the U.S. total (table 10). Based on U.S. Census Bureau statistics, the United States imported 14.7 Mt of salt from 48 countries in 2009, which was 7% more than was imported during 2008 (table 11). Canada was the leading source of imports, representing about 40% of total imports, followed closely by Chile (35%). Table 12 lists the imports of salt by customs districts. Of the 39 customs districts that imported salt in 2009, the New York, NY, customs district was the largest in terms of tonnage, accounting for about 18% of the total, followed by Detroit, MI (13%); Boston, MA (11%); Milwaukee, WI (10%); Chicago, IL (8%); Philadelphia, PA (8%); and Portland, ME (6%). The quantity of imported salt was about 10 times that of exports. Net salt imports also represented about 26% of U.S. apparent consumption. This indicates the magnitude of the U.S. reliance on salt imports. The majority of imported salt was brought into the country by foreign subsidiaries of major U.S. salt producers. Generally, imported salt can be purchased and delivered to many U.S. customers at prices lower than the comparable domestic product because production costs are lower abroad, currency exchange rates may favor the price of imported salt rather than the price of domestic salt, and ocean freight rates are less expensive than overland rail or truck rates.

World Review

Table 13 lists world salt production statistics for 113 nations based on reported and estimated information. In 2009, the total estimated world production increased to about 276 Mt. The United States remained a leading salt-producing country, representing 17% of total world output. China has rapidly increased its production. In 2009, estimated salt production in China was about 58 Mt, making it the leading salt producer in the world, or about 21% of total world output.

Most countries possess some form of salt production capability, with production levels set to meet their own domestic demand requirements and with additional quantities available for export to other countries. Many developing nations tend to develop their agricultural resources to feed their population first. Utilization of easily extractable mineral resources follows, and salt is one of the first mineral commodities to be mined. Some countries, such as the United States, import a substantial amount of salt to meet total demand requirements because of economic factors, as previously discussed.

Djibouti.—At Lake Assal between the cities of Tadjoura and Yoboki, Salt Investment S.A. built a new salt plant to serve the markets in eastern Africa. The country had provided Ethiopia with salt until Ethiopia imposed a 53% tariff on imports on salt from Djibouti in 2004 which affected salt production. Trade relations improved between the nations in 2006. The new salt project was expected to begin in mid-2010 (Industrial Minerals, 2009).

Outlook

The U.S. salt industry continued to be an important leader in terms of increased production, consumption, and world trade in salt. Despite the closing and idling of some chlorine plants since 2007 and the Nation's economic problems, the remaining chlorine facilities ran at lower capacity utilization rates, thereby reducing chlorine and caustic soda production as well as salt brine production and consumption. Because the chloralkali industry is energy intensive, any increase in energy prices is likely to reduce chlorine manufacture as well as salt brine usage. Solar salt and vacuum pan salt production and consumption have been constant and are expected to remain stable. U.S. salt production is expected to remain at the 2009 level through 2015. Rock salt production and consumption are heavily dependent on the severity of winter weather. Although the severity of the weather is virtually impossible to accurately forecast far in advance, the supplies of salt, from either domestic or imported sources, are more than adequate to meet any anticipated increase in demand.

Because salt is a relatively low-value commodity, the shipping cost for oceanic, rail, or truck transportation can be an important determining factor when attempting to secure supply sources from either domestic or foreign locations. If energy prices increase, one mode of transportation may be more cost-effective than others. Excluding deicing salt, domestic salt consumption may fluctuate but is likely to continue to increase in accordance with population growth. U.S. total salt production is expected to be an estimated 46 Mt in 2010.

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TABLE 1

SALIENT SALT STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2005	2006	2007	2008	2009
United States:					
Production:[2]					
Brine	19,900	19,800	19,700	18,900	17,800
Rock	17,700	16,500	16,800	20,900 r	20,300
Solar	3,430	3,640	3,650	4,070 r	3,880
Vacuum and open pans	4,170	4,450	4,420	4,200 r	4,030
Total	45,100	44,400	44,500	48,000 r	46,000
Sold or used by producers:					
Quantity	45,000	40,600	45,500	47,400 r	43,100
Value	1,310,000	1,310,000	1,520,000	1,690,000 r	1,750,000
Exports:					
Quantity	879	973	833	1,030	1,450
Value	51,800	54,900	59,600	65,900	74,100
Imports for consumption:					
Quantity	12,100	9,490	8,640	13,800	14,700
Value	180,000	163,000	171,000	282,000	337,000
Consumption:					
Apparent[3]	56,200	49,100	53,300	60,200 r	56,400
Reported	53,100	42,400	53,200	53,100	45,000
World, production	249,000 r	259,000 r	259,000 r	264,000 r	276,000

r Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes Puerto Rico.

[3] Sold or used plus imports minus exports.

TABLE 2
U.S. SALT COMPANIES BY PRODUCTION CAPACITY, LOCATION, AND TYPE IN 2009

(Thousand short tons)

Company	Rock	Solar	Vacuum and Open Pans	Brine
American Rock Salt Co., Hampton Corners, NY	4,500	--	--	--
Cargill, Inc.:				
Akron, OH	--	--	350	(1)
Avery Island, LA	2,700	--	--	(1)
Breaux Bridge, LA	--	--	200	--
Cleveland, OH	4,000	--	--	--
Freedom, OK	--	300	--	--
Lake Point, UT	--	800	--	--
Lansing, NY	2,400	--	--	--
Hutchinson, KS	--	--	450	--
Newark, CA	--	750	150	(1)
St. Clair, MI	--	--	425	--
Watkins Glen, NY	--	--	450	--
Corpus Christi Brine Services, Inc., Benavides, TX	--	--	--	(1)
Detroit Salt Co. LLC, Detroit, MI	1,500	--	--	--
Dow Chemical Co., The:				
Freeport, TX	--	--	--	(1)
Plaquemine, LA	--	--	--	(1)
E.I. duPont de Nemours, New Johnsonville, TN	--	--	230	--
Huck Salt Co., Fallon, NV	20	--	--	--
Hutchinson Salt Co., Hutchinson, KS	750	--	--	--
Independent Salt Co., Kanapolis, KS	750	--	--	--
Key Energy Services, LLC, Hobbs, NM[2]	--	--	--	(1)
Lyons Salt Co., Lyons, KS	600	--	--	--
Moab Salt, Inc., Moab, UT	--	250	--	--
Morton International, Inc.:				
Fairport, OH	2,000	--	--	--
Glendale, AZ	--	150	--	--
Grand Saline, TX	400	--	150	--
Grantsville, UT	--	500	--	--
Manistee, MI	--	--	360	--
Rittman, OH	--	--	600	--
Silver Springs, NY	--	--	375	(1)
South Hutchinson, KS	--	--	350	--
Weeks Island, LA	1,800	--	--	(1)
The Mosaic Co., Hersey, MI[3]	--	--	300	--
New Mexico Salt and Mineral Corp., Loving, NM	--	100	--	--
North American Salt Co.[4]				
Cote Blanche, LA	3,500	--	--	--
Lyons, KS	--	--	425	--
Ogden, UT[5]	--	1,500	--	--
Occidental Chemical Corp., Wichita, KS[6]	--	--	--	(1)
Olin Corp., McIntosh, AL	--	--	--	(1)
PPG Industries, Inc.:				
Lake Charles, LA	--	--	--	(1)
New Martinsville, WV	--	--	--	(1)

See footnotes at end of table.

TABLE 2—Continued
U.S. SALT COMPANIES BY PRODUCTION CAPACITY, LOCATION, AND TYPE IN 2009

(Thousand short tons)

Company	Rock	Solar	Vacuum and Open Pans	Brine
Redmond Clay & Salt Co., Inc., Redmond, UT	150	--	--	--
Searles Valley Minerals, Inc., Trona, CA[7]	--	200	--	--
South Bay Salt Works, Chula Vista, CA[8]	--	125	--	--
Tetra Technologies, Inc., Amboy, CA	--	75	--	--
Texas Brine Corp.:				
Beaumont, TX	--	--	--	(1)
Chacahoula, LA	--	--	--	(1)
Clemville, TX	--	--	--	(1)
Corpus Christi, TX	--	--	--	(1)
Dale, NY	--	--	--	(1)
Houston, TX	--	--	--	(1)
LaPorte, TX	--	--	--	(1)
Napoleonville, LA	--	--	--	(1)
Wyoming, NY	--	--	--	(1)
US Salt L.L.C., Watkins Glen, NY	--	--	335	(1)
Union Texas Products Corp., Plaquemine, LA	--	--	--	(1)
United Salt Corp.:				
Baytown, TX	--	--	400	(1)
Carlsbad, NM	--	400	--	--
Hockley, TX	150	--	--	--
Saltville, VA	--	--	200	--
Total Production Capacity	25,200	5,150	5,750	19,700

-- Zero.

[1] Includes brine for sale and for captive use. Individual brine capacity is assumed to be equal to the quantity of annual brine production, and therefore, considered company proprietary data. Brine producers include those chloralkali producers that produce captive brine and companies that supply brine for chloralkali manufacture, oil field chemicals, etc. Total brine production capacity is the quantity of brine produced for the year.

[2] Formerly Rowland Trucking Co., Inc.; then became Yale E. Key, Inc.

[3] Sells salt to North American Salt Co.

[4] Owned by Compass Minerals, Inc.

[5] Owned by Compass Minerals; operated by Great Salt Lake Minerals Corp.

[6] Formerly Vulcan Chemical Co.

[7] Formerly Pacific Salt and Chemical Co.

[8] Formerly Western Salt Co.

Source: U.S. Geological Survey.

TABLE 3

SALT PRODUCED IN THE UNITED STATES, BY TYPE AND PRODUCT FORM[1]

(Thousand metric tons)

Product form	Vacuum and open pans	Solar	Rock	Brine	Total
2008:					
Bulk	1,010 r	3,280 r	20,400 r	18,900	43,600 r
Compressed pellets	1,290	323	XX	XX	1,610
Packaged	1,770 r	396	294	XX	2,460 r
Pressed blocks	144	73	161	XX	379
Total	4,200 r	4,070 r	20,900 r	18,900	48,000 r
2009:					
Bulk	934	2,990	19,600	17,800	41,400
Compressed pellets	1,220	330	XX	XX	1,550
Packaged	1,730	465	522	XX	2,720
Pressed blocks	140	91	156	XX	387
Total	4,030	3,880	20,300	17,800	46,000

[r] Revised. XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 4

SALT SOLD OR USED IN THE UNITED STATES, BY TYPE AND PRODUCT FORM[1, 2]

(Thousand metric tons and thousand dollars)

	Vacuum and open pans		Solar		Rock		Brine		Total	
Product form	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
2008:										
Bulk	984 [r]	109,000 [r]	1,920 [r]	73,000 [r]	20,600	624,000	18,800	151,000 [r]	42,400 [r]	956,000 [r]
Compressed pellets	1,290	215,000	393	54,100	XX	XX	XX	XX	1,680	269,000
Packaged:										
Less-than-5-pound units	183 [r]	NA	10	NA	21	NA	XX	XX	214 [r]	XX
More-than-5-pound units	1,520 [r]	NA	892	NA	280	NA	XX	XX	2,700 [r]	XX
Total	1,710 [r]	307,000 [r]	902	79,600	301	32,900	XX	XX	2,910 [r]	420,000 [r]
Pressed blocks:										
For livestock	93	NA	115	NA	150	NA	XX	XX	358	XX
For water treatment	47	NA	2	NA	3	NA	XX	XX	51	XX
Total	140	17,900	117	13,800	153	16,100	XX	XX	410	47,800
Grand total	4,120 [r]	649,000 [r]	3,330 [r]	221,000 [r]	21,100	673,000	18,800	151,000 [r]	47,400 [r]	1,690,000 [r]
2009:										
Bulk	763	83,200	1,690	63,900	17,600	595,000	17,800	140,000	37,800	882,000
Compressed pellets	1,200	215,000	403	60,700	XX	XX	XX	XX	1,600	276,000
Packaged:										
Less-than-5-pound units	358	NA	1	NA	36	NA	XX	XX	395	XX
More-than-5-pound units	1,510	NA	921	NA	457	NA	XX	XX	2,890	XX
Total	1,870	385,000	922	92,700	493	56,100	XX	XX	3,280	534,000
Pressed blocks:										
For livestock	116	NA	129	NA	151	NA	XX	XX	396	XX
For water treatment	16	NA	1	NA	3	NA	XX	XX	20	XX
Total	132	18,800	130	18,000	154	17,200	XX	XX	416	53,900
Grand total	3,960	702,000	3,140	235,000	18,200	668,000	17,800	140,000	43,100	1,750,000

[r] Revised. NA Not available. XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] As reported at salt production locations, the term "sold or used" indicates that some salt, usually salt brine, is not sold but is used for captive purposes by plant or company. Because data do not include salt imported, purchased, and (or) sold from inventory from regional distribution centers, salt sold or used by type may differ from totals shown in tables 5 and 6, which are derived from company totals.

TABLE 5

SALT SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1, 2]

(Thousand metric tons and thousand dollars)

	2008		2009	
State	Quantity	Value	Quantity	Value
Kansas	3,010	178,000	2,710	188,000
Louisiana	14,600	231,000	13,200	229,000
New York	7,660	431,000	6,240	426,000
Texas	9,080	157,000	8,910	164,000
Utah	2,150	139,000	2,000	152,000
Other Eastern States[3]	9,460 [r]	455,000 [r]	8,680	480,000
Other Western States[4]	1,370 [r]	103,000 [r]	1,380	107,000
Total	47,400 [r]	1,690,000 [r]	43,100	1,750,000
Puerto Rico[e]	45	1,500	45	1,500

[e] Estimated. [r] Revised

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The term "sold or used" indicates that some salt, usually salt brine, is not sold but is used for captive purposes by plant or company.

[3] Includes Alabama, Michigan, Ohio, Tennessee, Virginia, and West Virginia.

[4] Includes Arizona, California, Nevada, New Mexico, and Oklahoma.

TABLE 6

DISTRIBUTION OF DOMESTIC AND IMPORTED SALT BY PRODUCERS IN THE UNITED STATES, BY END USE AND TYPE[1, 2]

(Thousand metric tons)

End use	Standard industrial classification	Vacuum and open pans 2008	Vacuum and open pans 2009	Solar 2008	Solar 2009	Rock 2008	Rock 2009	Brine 2008	Brine 2009	Total[3] 2008	Total[3] 2009
Chemical:											
Chloralkali producers	2812	100	82	332[r]	306	614	527	15,700	15,700	16,800	16,700
Other chemical	28 (excludes 2812, 2899)	255	205	262	200	1,350	832	1	6	1,860	1,240
Total		355	287	594[r]	506	1,960	1,360	15,700	15,800	18,600	17,900
Food-processing industry:											
Meat packers	201	209	205	50	42	24	24	--	--	283	271
Dairy	202	117	120	9	11	6	5	--	--	132	136
Canning	2091, 203	130	157	28	28	32	30	--	--	190	215
Baking	205	128	308	4	3	13[r]	12	--	--	144	324
Grain mill products	204 (excludes 2047)	84	85	6	5	17	9	--	--	107	100
Other food processing	206–208, 2047, 2099	714	493	80	103	73	77	1	1	869[r]	674
Total		1,380	1,370	177	193	164	158	1	1	1,720	1,720
General industrial:											
Textiles and dyeing	22	42	15	32	30	4	3	(4)	(4)	78	48
Metal processing	33, 34, 35, 37	8	4	18	11	16	8	(4)	(4)	42	24
Rubber	2822, 30 (excludes 3079)	3	2	(4)	(4)	2	2	(4)	(4)	6	5
Oil	13, 29	65	62	118	162	55	80	47	11	286	314
Pulp and paper	26	16	9	38	31	23	18	--	--	77	58
Tanning and (or) leather	311	2	1	9	8	26	22	--	--	37	32
Other industrial	XX	107	120	94	87	634	104	(4)	(4)	834	312
Total		243	213	308	329	759	238	48[r]	12	1,360	792
Agricultural:											
Feed retailers and (or) dealers mixers	5159	378	384	399	381	480	547	(4)	--	1,260	1,310
Feed manufacturers	2048	28	42	90	84	286	252	--	--	405	377
Direct-buying end user	02	5	3	8	8	12	10	--	--	25	21
Total		411	429	498	472	778	809	(4)	--	1,690	1,710
Water treatment:											
Government (Federal, State, local)	2899	21[r]	41	333	297	55	68	2	2	412	409
Commercial or other	2899	123	123	278	341	518[r]	128	2	9	922	602
Total		145	164	611	638	574	197	4	11	1,330	1,010
Ice control and (or) stabilization:											
Government (Federal, State, local)	9621	2	4	472	482	18,200	13,800	1	--	18,600	14,200
Commercial or other	XX	43	39	335	323	3,600	2,290	--	--	3,980	2,650
Total		45	43	807	805	21,800	16,000	1	--	22,600	16,900
Distributors:											
Agricultural distribution	5191	96	72	130	135	209	151	--	--	436	357
Grocery wholesalers and (or) retailers	514, 54	539	493	268	230	185	89	--	--	992	812
Institutional wholesalers and end users	58, 70	126	121	63	64	230	156	(4)	(4)	418	342
Water-conditioning distribution	7399	120	136	315	315	28	16	1	1	464	469
U.S. Government resale	9199	(4)	(4)	1	(4)	(4)	1	--	--	1[r]	1
Other wholesalers and (or) retailers	5251	801	769	994	904	374	258	(4)	(4)	2,170	1,930
Total		1,680	1,590	1,770	1,650	1,030	671	1	2	4,480	3,910
Other[5]		70	50	184	164	506	557	528	292	1,290	1,060
Grand total		4,330	4,150	4,950[r]	4,760	27,500	20,000	16,300	16,100	53,100	45,000

See footnotes at end of table.

TABLE 6—Continued

DISTRIBUTION OF DOMESTIC AND IMPORTED SALT BY PRODUCERS IN THE UNITED STATES, BY END USE AND TYPE[1, 2]

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[r] Revised. -- Zero. XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The quantity of imports included in the total for each type of salt is the amount reported by the U.S. salt industry, not the quantity reported by the U.S. Census Bureau that appears in tables 1, 11, and 12.

[3] Because data include salt imported, produced, and (or) sold from inventory from regional distribution centers, data for salt sold or used by type may differ from totals shown in tables 1, 3, and 4, which are derived from plant reports at salt production locations. Data may differ from totals shown in table 6 because of changes in inventory and (or) incomplete data reporting.

[4] Less than ½ unit.

[5] Includes exports.

TABLE 7

DISTRIBUTION OF DOMESTIC AND IMPORTED EVAPORATED AND ROCK SALT IN THE UNITED STATES, BY DESTINATION[1, 2]

(Thousand metric tons)

	2008				2009			
	Evaporated				Evaporated			
Destination	Vacuum and open pans	Solar	Rock	Total	Vacuum and open pans	Solar	Rock	Total
Alabama	50	5	67	123	42	7	52	101
Alaska	3	3	--	6	3	2	--	5
Arizona	11	105	1	118 r	12	110	1	123
Arkansas	51	5	74	130	46	6	56	108
California	206	715 r	2	922 r	196	754	6	956
Colorado	12	71	8	91	11	66	10	87
Connecticut	14	109	140	263	16	115	115	245
Delaware	10	11	3	25	11	10	2	23
District of Columbia	(3)	16	4	20	(3)	33	2	35
Florida	75	208	3	286	71	215	4	291
Georgia	113	68	33	214	103	55	36	195
Hawaii	(3)	1	--	2	13	55	(3)	69
Idaho	20	127	1	147 r	8	39	(3)	48
Illinois	307	132	3,230	3,670	318	99	2,170	2,590
Indiana	249	116	1,110	1,470 r	249	121	729	1,100
Iowa	131	111	938	1,180	127	99	434	659
Kansas	88	59	987	1,130	76	44	1,140	1,260
Kentucky	68	8	875	951	64	7	830	900
Louisiana	61	4	437	502	66	4	235	306
Maine	11	9	225	245	15	8	148	172
Maryland	66	131	17	214	77	167	20	264
Massachusetts	28	8	321	357	32	48	302	382
Michigan	274	42	2,980	3,300	268	42	1,950	2,260
Minnesota	126	305	880	1,310	114	223	635	973
Mississippi	22	2	239	263	21	4	174	198
Missouri	155	78	585	818	119	71	414	604
Montana	1	53	(3)	54	1	68	(3)	69
Nebraska	56	42	38	135	56	39	23	118
Nevada	4	239 r	(3)	244 r	4	211	19	235
New Hampshire	15	37	216	269	15	108	53	176
New Jersey	97	155	78	330	104	118	112	334
New Mexico	17	81	(3)	98	20	133	(3)	153
New York	295	71	4,180	4,540	179	35	3,060	3,280
North Carolina	134	62	81	276	113	97	74	283
North Dakota	24	14	6	45	16	15	6	37
Ohio	419	45	3,510	3,970	426	40	2,090	2,550
Oklahoma	33	26	76	134	30	27	62	119
Oregon	19	43	1	63	19	39	1	59
Pennsylvania	166	58	2,340	2,560	172	76	1,920	2,170
Rhode Island	3	190	1	195	3	227	1	231
South Carolina	44	9	1	54	44	9	2	55
South Dakota	21	56	18	94 r	23	54	9	86
Tennessee	110	6	423	539	123	6	366	495
Texas	277	167	172	616	278	158	208	646
Utah	14	503	1	518	14	307	10	331
Vermont	6	2	296	303	5	1	218	225
Virginia	87	60	87	233	88	77	117	281

See footnotes at end of table.

TABLE 7—Continued

DISTRIBUTION OF DOMESTIC AND IMPORTED EVAPORATED AND ROCK SALT IN THE UNITED STATES, BY DESTINATION[1, 2]

(Thousand metric tons)

	2008				2009			
	Evaporated				Evaporated			
Destination	Vacuum and open pans	Solar	Rock	Total	Vacuum and open pans	Solar	Rock	Total
Washington	26	126	1	154	25	134	1	159
West Virginia	16	49	261	326	20	7	147	173
Wisconsin	220	189	2,120	2,520	199	158	1,520	1,870
Wyoming	1	37	(3)	38	1	47	(3)	49
Other[4]	78	182	457	718	86	164	555	804
Total[5]	4,330	4,950 r	27,500	36,800	4,150	4,760	20,000	28,900

[r]Revised. -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Each salt type includes domestic and imported quantities. Brine is excluded because brine is not shipped out of State.

[3]Less than ½ unit.

[4]Includes shipments to overseas areas administered by the United States, Puerto Rico, exports, and some shipments to unspecified destinations.

[5]Because data include salt imported, purchased, and (or) sold from inventory from regional distribution centers, data for evaporated and rock salt distributed by State may differ from totals shown in tables 1 and 3, which are derived from plant reports at salt production locations. Data may differ from totals shown in table 5 because of changes in inventory and (or) incomplete data reporting.

TABLE 8

AVERAGE VALUE OF SALT, BY PRODUCT FORM AND TYPE[1, 2]

(Dollars per metric ton)

Product form	Vacuum and open pans	Solar	Rock	Brine
2008:				
Bulk	110.73 r	38.06 r	30.25	7.99 r
Compressed pellets	166.74	137.72	XX	XX
Packaged	180.03 r	88.25	109.46	XX
Average[3]	158.59 r	64.33 r	31.39	7.99 r
Pressed blocks	128.31	118.66	104.78	XX
2009:				
Bulk	109.05	37.84	33.90	7.85
Compressed pellets	180.00	150.42	XX	XX
Packaged	206.27	100.56	113.74	XX
Average[3]	178.67	72.09	36.08	7.85
Pressed blocks	142.57	138.06	111.79	XX

[r]Revised. XX Not applicable.

[1]Net selling value, free on board plant, excluding container costs.

[2]Data are rounded to no more than three significant digits; may not add to totals shown.

[3]Salt value data reported prior to 1984 were an aggregate value per metric ton of bulk, compressed pellets, and packaged salt. For time series continuity, an average of these three types of product forms is presented that is based on the aggregated values and quantities of the product form for each type of salt listed in table 3.

TABLE 9

U.S. EXPORTS OF SALT, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

Country	2008		2009	
	Quantity	Value[2]	Quantity	Value[2]
Canada	896	42,200	1,360	50,200
China	6	878	1	528
Colombia	2	409	2	341
Costa Rica	2	303	2	362
Dominican Republic	1	359	1	393
Germany	1	271	1	475
Honduras	4	515	1	332
Japan	9	2,230	3	1,560
Malaysia	3	558	3	826
Mexico	36	6,030	45	7,560
Netherlands	31	2,190	1	704
Panama	1	145	1	133
Saudi Arabia	5	1,230	4	1,190
Singaore	3	190	1	543
Other	25 r	8,410 r	20	8,950
Total	1,030	65,900	1,450	74,100

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown. (The Harmonized Tariff Schedule of the United States code for salt is 2501.00.0000.)

[2] Free alongside ship value at U.S. ports.

Source: U.S. Census Bureau.

TABLE 10

U.S. EXPORTS OF SALT, BY CUSTOMS DISTRICT[1]

(Thousand metric tons and thousand dollars)

	2008		2009	
District	Quantity	Value[2]	Quantity	Value[2]
Anchorage, AK	2	358	(3)	27
Buffalo, NY	34	6,680	30	5,850
Cleveland, OH	(3)	107	1	163
Detroit, MI	719	22,100	1,200	30,900
El Paso, TX	1	169	1	360
Great Falls, MT	1	445	2	644
Houston, TX	43	4,100	9	3,200
Laredo, TX	27	4,960	36	5,700
Los Angeles, CA	26	4,810	5	3,400
Miami, FL	4	1,380	3	1,410
Mobile, AL	(3)	75	(3)	36
New York, NY	9	3,470	1	192
Nogales, AZ	1	305	4	1,270
Norfolk, VA	1	551	1	594
Ogdensburg, NY	21	3,440	23	3,940
Pembina, ND	3	883	5	1,080
San Diego, CA	6	580	3	251
San Francisco, CA	3	596	3	995
Seattle, WA	8	1,620	5	1,440
St. Albans, VT	6	726	4	710
Other[4]	116	8,560	119	11,900
Total	1,030	65,900	1,450	74,100

[1] Data are rounded to no more than three significant digits; may not add to totals shown. (The Harmonized Tariff Schedule of the United States code for salt is 2501.00.0000.)

[2] Free alongside ship value at U.S. ports.

[3] Less than ½ unit.

[4] Unknown but assumed to be rail and (or) truck shipments to Canada through various points of departure. Also includes minor shipments through 15 other customs districts.

Source: U.S. Census Bureau.

TABLE 11

U.S. IMPORTS FOR CONSUMPTION OF SALT, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

Country	2008		2009	
	Quantity	Value[2]	Quantity	Value[2]
Australia	2	187	1	175
Bahamas, The	578	7,510	811	12,600
Belgium	2	709	4	840
Brazil	393	9,500	168	3,060
Canada	4,740	107,000	5,940	131,000
Chile	4,680	67,100	5,170	107,000
China	13	2,150	9	1,390
Colombia	4	650	5	825
Egypt	620	5,770	291	5,560
France	82	13,400	17	6,790
Germany	2	1,260	9	1,340
Israel	11	1,930	9	3,840
Italy	62	3,440	70	3,830
Korea, Republic of	4	981	1	864
Mexico	1,180	31,900	1,260	33,400
Netherlands	100	4,690	217	6,410
Netherlands Antilles	154	2,970	28	1,010
New Zealand	2	178	(3)	65
Pakistan	15	575	2	627
Peru	587	6,270	408	4,150
South Africa	2	1,210	4	1,300
Spain	30	3,470	65	3,660
Tunisia	101	1,720	54	589
United Kingdom	497	5,890	67	2,690
Other	20 r	1,790 r	81	3,040
Total	13,900	282,000	14,700	337,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown. (The Harmonized Tariff Schedule of the United States code for salt is 2501.00.0000.)

[2] Customs value only.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 12
U.S. IMPORTS OF SALT, BY CUSTOMS DISTRICT[1]

(Thousand metric tons and thousand dollars)

District	2008		2009	
	Quantity	Value[2]	Quantity	Value[2]
Anchorage, AK	21	1,330	3	167
Baltimore, MD	1,170	25,400	850	27,600
Boston, MA	1,480	18,300	1,630	25,400
Buffalo, NY	29	924	5	583
Charleston, SC	103	2,060	82	1,610
Chicago, IL	1,050	16,800	1,170	18,200
Cleveland, OH	190	6,790	246	4,710
Columbia-Snake, OR	165	5,340	145	4,880
Dallas-Fort Worth, TX	2	415	(3)	81
Detroit, MI	1,550	33,000	1,890	33,300
Duluth, MN	56	4,860	36	3,230
Great Falls, MT	8	702	2	226
Los Angeles, CA	164	5,130	116	4,610
Miami, FL	2	412	1	336
Milwaukee, WI	1,090	16,300	1,470	20,400
Minneapolis, MN	144	2,560	277	4,110
New Orleans, LA	1,120	23,500	484	13,200
New York, NY	2,010	33,900	2,600	55,000
Norfolk, VA	71	1,470	47	866
Ogdensburg, NY	382	20,800	749	45,000
Pembina, ND	5	851	4	795
Philadelphia, PA	930	13,200	1,150	24,400
Portland, ME	1,290	20,400	854	14,400
Providence, RI	227	3,450	235	5,500
San Diego, CA	6	1,010	4	1,150
San Francisco, CA	1	1,080	3	1,230
San Juan, PR	4	674	5	883
Savannah, GA	56	2,260	39	2,230
Seattle, WA	16	1,630	119	5,670
St. Albans, VT	6	747	2	278
St. Louis, MO	48	3,220	(3)	79
Tampa, FL	367	6,410	356	6,900
Wilmington, NC	113	5,320	119	4,490
Other[4]	3	1,890	6	5,280
Total	13,900	282,000	14,700	337,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown. (The Harmonized Tariff Schedule of the United States code for salt is 2501.00.0000.)

[2] Customs value only.

[3] Less than ½ unit.

[4] Includes imports through 6 other customs districts.

Source: U.S. Census Bureau.

TABLE 13

SALT: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Afghanistan, rock salt[e]	12	12	12	12	12
Albania[e]	25	25	25	25	25
Algeria, brine and sea salt	197	260	183	202	200
Angola[e]	30	35	35	35	35
Argentina	1,846	1,918	2,358	1,681 [r]	1,700
Armenia	35	37	35	37	37
Australia, salt and marine salt	12,444	11,424	10,855	11,160 [r]	11,000
Austria, rock and brine	1,024	807	742	1,134 [r]	1,000
Azerbaijan	11	12	7	8 [r]	5 [4]
Bahamas, The	1,270	1,152	8,823 [r]	10,244 [r]	10,000
Bangladesh, marine salt[e, 5]	350	350	360	360 [r]	350
Belarus[e]	1,839 [4]	1,900	2,000	2,000	2,000
Bolivia	1	1	2	1 [r]	2 [4]
Bosnia and Herzegovina	392	416	502	555 [r]	550
Botswana[e, 6]	210 [4]	210	210	210	210
Brazil:					
Brine salt	5,520	5,122	5,365 [r]	5,370 [r, e]	5,370
Rock salt	1,559	1,624	1,621 [r]	1,650 [r, e]	1,650
Total	7,079	6,746	6,986 [r]	7,020 [r, e]	7,020
Bulgaria	1,900	2,000	2,000 [e]	2,100 [r, e]	2,100
Burkina Faso[e]	5	5	5	5	5
Burma, brine salt	117	84	71	54	133 [4]
Cambodia	--	59 [r]	77 [r]	78 [r]	78
Canada	13,643	14,389	11,862	14,386	14,566 [4]
Cape Verde[e]	2	2	2	2	2
Chile	6,068	4,580	4,404	6,431	8,382 [4]
China	46,610	56,630	59,760	59,520	58,450 [4]
Colombia:					
Marine salt	429	390	310	178 [r]	150
Rock salt	216	248	204	43 [r]	100
Total	645	638	514	221 [r]	250
Costa Rica, marine salt[e]	20	20	20	-- [r]	--
Croatia	37	30	33	33 [e]	32
Cuba	351	266	141 [r]	157 [r]	160
Denmark, sales[e]	610	600	600	600	600
Djibouti[e]	53	78	98	118	118
Dominican Republic, marine salt[e]	50	50	50	50	50
Ecuador[e]	75	75	75	75	75
Egypt[e]	1,200	1,200	227 [r, 4]	271 [r, 4]	300
El Salvador, marine salt[e]	31	30	30	30	30
Eritrea, marine salt[e]	63	60	60	60	60
Ethiopia, rock salt[5]	87	218	240	260	281 [4]
France, all sources[7]	6,730	8,718	6,140	6,100 [r]	6,100
Georgia[e]	30	30	30	30	30
Germany:					
Industrial brines	9,904	9,590	10,395 [r]	9,084 [r]	9,000
Rock salt and other	8,834	9,663	7,819	5,855 [r]	5,500
Salt, evaporated, includes marine salt	594	593	592 [r]	580 [r]	550
Total	19,333	19,846	18,806 [r]	15,519 [r]	15,100
Ghana[e]	250	123 [r]	124 [r]	150 [r]	150
Greece[e]	150	150	150	150	150

See footnotes at end of table.

TABLE 13—Continued

SALT: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Guadeloupe[e]	49	49	49	49	49
Guatemala[e]	60	50	50	50	50
Guinea[e]	15	15	15	15	15
Honduras[e]	42	40	40	40	40
Iceland[e]	5	5	5	5	5
India:[e]					
Marine salt	15,500	15,500	16,000	16,000	16,500
Rock salt	3	3	3	3	3
Total	15,500	15,500	16,000	16,000	16,500
Indonesia[e]	680	700	700	700	720
Iran[e, 8]	2,009 [4]	2,000	2,565 [r, 4]	2,000	2,000
Iraq[e]	25	25	153 [r]	109 [r]	150
Israel	406	434	400	421 [r]	420
Italy, all sources[9]	3,476	3,438	2,214	2,200 [e]	2,200
Jamaica[e]	19	19	19	NA [r]	NA
Japan	1,227	1,166	1,190 [e]	1,200 [e]	1,200
Jordan	30	29	17	29	30
Kazakhstan, salt and sodium chloride	178	417	228	225 [e]	213 [4]
Kenya, crude salt[10]	27 [r]	35 [r]	12 [r]	24 [r]	24
Korea, North[e]	500	500	500	500	500
Korea, Republic of	379 [r]	286 [r]	250 [r]	348 [r]	350
Kuwait[e]	8	13	14	14 [r]	14
Laos, rock salt[e]	34 [4]	35	35	35	35
Lebanon[e]	4	4	4	4	4
Libya[e]	40	40	40	40	40
Madagascar[e]	65	75	75	75	75
Mali[e]	6	6	6	6	6
Malta, marine salt[e]	(11)	(11)	(11)	(11)	(11)
Martinique[e]	200	200	200	200	200
Mauritania	(11) [e]	(11)	(11)	1	1 [4]
Mauritius	8	9	8	8 [e]	8
Mexico	9,508	8,371	8,400 [e]	8,809	7,445 [4]
Mongolia, mine output	2	1	1	(11) [r]	1
Montenegro, sea water evaporate	15 [12]	5	20 [e]	25 [e]	17
Morocco, marine and rock salt	254	250	250 [e]	250 [e]	250
Mozambique, marine salt[e]	140 [r]	150 [r]	110 [r]	110 [r]	110
Namibia, marine salt	573	604	811 [r]	732 [r]	700
Nepal[e, 13]	2	--	2 [r]	2 [r]	2
Netherlands[e]	5,000	5,000	5,000	5,000	5,000
Netherlands Antilles[e]	500	500	500	500	500
New Zealand[e]	100	100	100	100	100
Nicaragua, marine salt[e]	30	30	30	30	30
Niger[e]	1 [4]	1	1	1	1
Oman	11	11	10	10	11
Pakistan:[5]					
Marine salt[e]	14	13	13	13	13
Rock salt	1,648	2,008	1,620	1,700 [r]	1,750
Total	1,662	2,021	1,633	1,713 [r]	1,760
Panama, marine salt[e]	18	18	18	18	18
Peru	1,255	1,253	1,185	1,276	15,668 [4]
Philippines, marine salt	421	418	438	510 [r]	500

See footnotes at end of table.

TABLE 13—Continued

SALT: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Poland:					
Rock salt	1,123	1,130	591	618 [r]	620
Recovered from brine	2,900 [r]	2,899 [r]	2,931 [r]	2,900 [r, e]	2,900
Portugal, rock salt	598	586	591 [r]	560 [r]	560 [p, 4]
Total	4,023 [r]	4,029 [r]	3,522 [r]	3,518 [r]	3,520
Romania:					
Rock salt	46	47	51	50 [e]	50
Other	2,374	2,574	2,425	2,400 [r, e]	2,400
Total	2,420	2,621	2,476	2,450 [r, e]	2,450
Russia	2,700	2,900	2,200	2,200 [e]	2,200
Saudi Arabia	1,738	1,752	1,507 [r]	1,600 [r]	1,600
Senegal	134	199	212	241 [r]	200
Serbia	35 [e, 12]	30	30	30 [r]	29 [4]
Slovakia	100 [r]	99 [r]	101 [r]	100 [r, e]	100
Slovenia	803	803	803 [e]	803 [e]	803
South Africa	399	465	412	416	425 [4]
Spain:					
Marine and other evaporated salt	1,350	1,469 [r]	1,500 [r]	1,500 [r, e]	1,500 [p]
Rock salt	3,200	2,834 [r]	2,850 [r]	2,850 [r, e]	2,850 [p]
Total	4,550	4,303 [r]	4,350 [r]	4,350 [r, e]	4,350 [p]
Sri Lanka[e]	80	88	70	70	72
Sudan	30 [e]	12	23	23 [e]	23
Switzerland[e]	300	300	300	300	300
Syria	110	133	81	81 [e]	78 [4]
Tanzania	135	35	35	36 [e]	36
Thailand:					
Rock salt	1,074	1,008	1,135 [r]	1,212 [r]	1,200
Other[e]	100	100	100	100	100
Total	1,174	1,108	1,235 [r]	1,312 [r]	1,300
Tunisia, marine salt	1,132	1,127	933	1,063 [r]	1,000
Turkey	2,253	2,800	1,500	1,500 [e]	1,500
Turkmenistan[e]	215	215	215	215	215
Uganda[e]	5	5	5	5	5
Ukraine	4,811	5,996	5,548	4,425 [r]	4,400
United Kingdom:[e]					
Brine salt[14, 15]	2,800	2,800	2,800	2,800	2,800
Rock salt	2,000	2,000	2,000	2,000	2,000
Other salt[15]	1,000	1,000	1,000	1,000	1,000
Total	5,800	5,800	5,800	5,800	5,800
United States, including Puerto Rico:					
United States:					
Brine	19,900	19,800	19,700	18,900	17,800 [4]
Rock salt	17,700	16,500	16,800	20,900 [r]	20,300 [4]
Solar salt	3,430	3,640	3,650	4,070 [r]	3,880 [4]
Vacuum and open pan	4,170	4,450	4,420	4,200 [r]	4,030 [4]
Puerto Rico[e]	45	45	45	45	45
Total	45,200	44,500	44,600	48,100 [r]	46,100 [4]
Venezuela[e]	350	350	350	350	350
Vietnam	898	842 [r]	857 [r]	847 [r]	850
Yemen[e]	90	100 [4]	100	100	100
Grand total	249,000 [r]	259,000 [r]	259,000 [r]	264,000 [r]	276,000

[e]Estimated. [p]Preliminary. [r]Revised. – Zero. NA not available.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 13—Continued
SALT: WORLD PRODUCTION, BY COUNTRY[1, 2]

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[2] Table includes data available through July 16, 2010.

[3] Salt is produced in many other countries, but quantities are relatively insignificant and reliable production data are not available. Some salt brine production data for manufacture of chlorine, caustic soda, and soda ash are not reported because of incomplete data reporting by many countries.

[4] Reported figure.

[5] Year ending June 30 of that stated.

[6] From natural soda ash production.

[7] Includes marine and rock salt and salt solution.

[8] Year beginning March 21 of that stated.

[9] Includes marine salt.

[10] Production by Magadi Soda Ash Ltd. Only.

[11] Less than ½ unit.

[12] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[13] Does not include production from Sardinia and Sicily, which is estimated to be 200,000 metric tons per year.

[14] Year ending July 15 of that stated.

[15] Data captioned "Brine salt" for the United Kingdom are the quantities of salt obtained from the evaporation of brine; that captioned "Other salt" are for salt content of brines used for purposes other than production of salt.

SAND AND GRAVEL, CONSTRUCTION

By Wallace P. Bolen

Domestic survey data and tables were prepared by Hodan A. Fatah, Martha L. Jackson, and Forest H. Morgan, statistical assistants.

A total of 836 million metric tons (Mt) of construction sand and gravel was produced in the United States in 2009. This was a decrease of 221 Mt, or 21%, from the revised production of 2008. This was the third consecutive decrease in annual production and reflected continuing low demand from most building and highway construction markets. The last time there were three consecutive years of decreasing sand and gravel production was in 1981 through 1983. The 836 Mt was the lowest production since 1992 when 834 Mt was produced.

Construction sand and gravel is a traditional basic building material and is one of the earliest materials used by humanity for dwellings and later for outdoor areas such as paths, roadways, and other constructs. Sand and gravel is very accessible and is widely used throughout the United States and the world. As sand and gravel became less available owing to resource restraint or economic conditions in some locales, builders began to crush bedrock to produce a manufactured sand and gravel often referred to as crushed stone. Sand and gravel and crushed stone combined are defined as construction aggregate. The crushed stone industry is reviewed in a separate chapter of the U.S. Geological Survey (USGS) Minerals Yearbook; both of these mineral commodities are usually included in reviews of national, State, or local aggregates industries. All percentages in this report were computed using unrounded data.

The decrease in sand and gravel consumption in 2009 was a reflection of the decrease in the total construction put in place as reported by the U.S. Census Bureau. Total construction declined by about 15% in 2009 compared with that in 2008. Both residential and nonresidential construction declined in 2009, 29% and 8%, respectively. Only 6 of 16 nonresidential categories of construction increased in 2009: power (10.3%), manufacturing (9.9%), transportation (8.4%), public safety (7.8%), conservation and development (7.5%), and highway and street (0.8%) (U.S. Census Bureau, 2011).

Each year, hundreds of sand and gravel operations are idled, closed, or abandoned, and hundreds more are reactivated or opened. The changing location of construction and highway projects is the major factor in decisions to open, idle, or close operations.

In the United States in 2009, 6,437 construction sand and gravel operations were active (table 6A), 855 operations were reported as idle, and 320 operations either were reported to be closed or were assumed to be permanently shut down. Of the 6,437 active operations, 63 were classified as sales or distribution yards only; a sales yard is defined as a fixed location that receives sand and gravel from a distant source and sells it at the yard. In addition, 61 operations reported that they were either an open pit or a dredge combined with a sales yard that supplemented local production with material from a remote location. A small number of the idle sand and gravel operations reported recycling of asphalt and portland cement concrete but no sand and gravel mining. The 6,437 operations with 7,806 active sand and gravel pits were owned by 3,956 companies or government agencies operating in all 50 States. A review of the data provided by the U.S. Mine Safety and Health Administration (MSHA) revealed 687 previously unaccounted for sand and gravel locations that reported at least 500 employee hours of activity during 2009. Prior to this report, only operations with at least 2,000 employee hours were added to this survey. For 2009, however, operations with as little as 500 hours were added in order to more accurately account for the many smaller operators that consistently produce but were sometimes overlooked in previous surveys. Information was gathered from these newly recognized operations and included in this report. In 2009, of the 6,437 active operations surveyed, 3,049, or 47%, responded to the USGS canvass. Their total production represented 50% of the 836 Mt produced in 2009. Estimates for operations that did not report were based on prior year estimates and MSHA employee hour reports.

According to the U.S. Census Bureau, in 2009 exports increased by 12% to 439,000 metric tons (t), and the value increased by 3% to $23 million compared with the 2008 data (tables 1, 12). Imports of construction sand and gravel decreased sharply after rising by 23% in 2008 compared with those in 2007. In 2009, imports decreased by 45% to about 3 Mt, and the value decreased by 42% to $66 million (tables 1, 13). Imports have become a significant source for sand and gravel in some areas of the country, although imports were down about 58% since 2005. Domestic apparent consumption of construction sand and gravel, which is defined as production for consumption (sold or used) plus total imports minus total exports, was 839 Mt.

Production

Of the four major geographic regions, the West again led the Nation in the production of construction sand and gravel in 2009 with 309 Mt, or 37% of the U.S. total (table 2). The West was followed by the Midwest with 234 Mt, or 28%; the South with 199 Mt, or 24%; and the Northeast with 94 Mt, or 11%. Compared with that of 2008, production decreased in all four regions in 2009.

Of the nine geographic divisions, the Mountain division led the Nation in the production of construction sand and gravel in 2009 with 179 Mt, or 21% of the U.S. total, and was followed by the East North Central with 132 Mt, or 16%, and the Pacific with 130 Mt, or 15% (table 2). Production decreased in all nine divisions compared with that of 2008 ranging from a 34% decline in the South Atlantic division to 9% in the West North Central division.

In 2009, construction sand and gravel was produced in every State (table 3). The leading States were, in descending order of tonnage, California, Texas, Arizona, Michigan, Utah, New York, Minnesota, Washington, Colorado, and Wisconsin. The combined production of these 10 States represented about 49% of the national total. Production increased in three States—Arkansas, New Mexico, and North Dakota, and decreased in the other 47 States compared with that of 2008. Production decreases of greater than 30% were reported in seven States—Florida (45%), Arizona (40%), South Carolina (39%), Alaska (36%), Maryland (34%), Idaho (31%), and Hawaii (31%).

A review of the production of construction sand and gravel for consumption by size of operation indicates that about 50% of the total production came from 2,121 operations that reported between 100,000 and 499,999 metric tons per year (t/yr); 22% of the construction sand and gravel produced came from 295 operations that reported between 500,000 and 999,999 t/yr; and 14% came from 75 operations that reported 1 million metric tons per year (Mt/yr) production or more. The largest number of operations (3,946, or 61% of total operations) produced less than 100,000 t/yr (15% of the total production) (table 6A).

In 2009, the leading domestic commercial producers of construction sand and gravel were, in descending order of production, Oldcastle Materials, Inc.; CEMEX S.A.B. de C.V.; Vulcan Materials Co.; Lehigh Hanson, Inc.; MDU Resources Group, Inc./Knife River Corp.; Holcim Group/Aggregate Industries Management, Inc.; Mitsubishi Materials Corp.; Lafarge North America, Inc.; Martin Marietta Aggregates; and Fisher Industries, Inc. The combined production of these 10 companies was about 165 Mt, or about 20% of the national total. The top 100 producers of construction sand and gravel in the United States in 2009 are listed in table 14.

Some information about the production of construction sand and gravel in foreign countries can be found in the U.S. Geological Survey Minerals Yearbook, volume III, Area reports—International. For nonreporting countries, estimates of sand and gravel and crushed stone production can be based on indirect indicators, such as the levels of asphalt and cement consumption.

Consumption

Production of construction sand and gravel reported to the USGS by producers was material that was sold or used by the companies. Stockpiled production is not reported until it is sold or consumed by the producer. Because no consumption surveys are conducted by the USGS for sand and gravel, the sold or used tonnage is assumed to represent the amount produced for domestic consumption and export. Because some of the construction sand and gravel producers did not report a breakdown by end use, their total production was reported under "Unspecified uses, reported." The estimated production of nonrespondents was reported under "Unspecified uses, estimated."

Of the 836 Mt of construction sand and gravel produced in 2009, 63% was for unspecified uses (tables 4, 5). Of the remaining 310 Mt, 41% was used as concrete aggregate; 25% was used for road base and coverings and road stabilization; 13%, for construction fill; 12%, for asphaltic concrete aggregate and other bituminous mixtures; 4%, for plaster and gunite sands; and the remaining 5% was used for concrete products, such as blocks, bricks, and pipes; golf course maintenance; filtration; railroad ballast; roofing granules; snow and ice control; and many other miscellaneous uses.

To provide a more accurate estimate of the consumption patterns for construction sand and gravel, the unspecified uses are not included in the above percentages. In any marketing or use-pattern analysis, the total quantities included in "Unspecified uses" may be distributed among the reported use categories by applying the above percentages.

Additional information regarding production or consumption of construction sand and gravel by major uses in each State and State district can be found in the U.S. Geological Survey Minerals Yearbook, volume II, Area reports—Domestic.

Recycling

Beginning with the 2008 survey, the USGS began collecting recycling statistics from construction and demolition companies. Although not all of the companies surveyed responded to the request for information on concrete and asphalt recycling, many did. These data have been combined with recycling data received from aggregate mining companies, both crushed stone and sand and gravel producers. Recycling in this industry generally refers to the crushing, screening, and reuse of asphalt and cement concretes. Aggregates, construction, and demolition companies and related asphalt and ready-mix companies are often involved in construction projects during which they collect and reuse the materials at the site. Sometimes construction companies haul their materials to a recycling location where the asphalt or concrete is processed for reuse. The USGS welcomes additional information on recycling and encourages all construction materials recycling companies to provide statistics on their activities. Companies involved in recycling may contact the author of this report to receive more information on how to report.

Recycled Asphalt.—In 2009, 16 Mt of asphalt concrete valued at $170 million was recycled by aggregate, construction, and demolition companies in 49 States and Puerto Rico (table 10). The leading States, all with more than 600,000 tons of recycled asphalt, were, in descending order of tonnage recycled, California, Illinois, Kansas, Pennsylvania, Florida, North Carolina, New Mexico, Wisconsin, Texas, and Michigan.

Recycled Concrete.—In 2009, about 13 Mt of cement concrete valued at $103 million was recycled in 49 States (table 11). The leading States, all with more than 500,000 tons of recycled concrete, were, in descending order of tonnage recycled, California, Illinois, Michigan, Texas, Minnesota, Colorado, Virginia, New Jersey, Kentucky, and Florida. Information regarding the method of transportation of construction sand and gravel from the pit or processing plant to the first point of sale or use is available for each geographic division and the total United States.

Transportation

Reports regarding the method of transportation were provided by the producers for 227 Mt, or 27% of the total U.S. production of construction sand and gravel in 2009. Of this total, 81% was transported by truck; 3%, by waterway; and less than 1%, by rail (table 7). A significant amount of construction sand and gravel produced (about 15%) was not transported and was used at or near the production site, probably for asphalt or cement concrete production. Because most producers neither keep records of nor report shipping distances or cost per metric ton per mile, transportation cost data are not available.

Prices

Prices in this chapter are free on board (f.o.b.) plant, usually the first point of sale or captive use. This value does not include transportation from the plant or yard to the consumer. It does include all costs of mining, processing, in-plant transportation, overhead, and profit.

The 2009 average unit price increased slightly to $7.57 per metric ton compared with that of 2008. By use, the unit prices varied from a high of $20.39 per metric ton for roofing granules to a low of $4.65 per metric ton for fill (table 4). The largest increases in unit price were recorded for concrete products (17.6%), road stabilization, lime (13.8%), and road stabilization, cement, (10.6%). The largest decreases were for filtration (28.5%), railroad ballast (18.1%), and plaster and gunite sands (11.3%).

The States having the highest unit price per metric ton were, in descending order, Rhode Island ($12.79), Hawaii ($12.70), Maryland ($12.43), Delaware ($11.80), California ($11.52), Virginia ($11.38), Connecticut ($10.70), and New Jersey ($10.49). The States having the lowest unit price per metric ton were, in ascending order, North Dakota ($3.28), South Dakota ($3.59), Wisconsin ($4.92), Kansas ($5.04), and Michigan ($5.09). The unit value decreased in 18 States and increased in the other 32 States (table 3). The States having the largest increases in unit value were, in descending order, Delaware (46%), New Hampshire (28%), Ohio (23%), Vermont (21%), Maryland (19%), Nevada (17%), and South Carolina (16%). The States having the largest decreases in unit value were, in descending order, Hawaii (30%), Indiana (11%), Oklahoma (9%), Wyoming (9%), and New Mexico (8%).

Foreign Trade

The widespread distribution of domestic sand and gravel deposits and the high cost of transportation limit foreign trade to mostly local transactions across international boundaries. U.S. imports and exports represented less than 1% of domestic consumption.

According to the U.S. Census Bureau, exports of construction sand decreased by about 19% to 79,000 t compared with that of 2008, but the value increased by about 6% to $19 million (table 12). Canada, which was the leading destination, received about 25% of the total sand, followed by the Middle East (24%), The Bahamas (9%), and Mexico (3%). Exports of construction gravel increased by 22% to 360,000 t compared with those of 2008, but the value decreased by about 7% to $4.1 million. Canada, which was the leading destination, received about 91% of the total gravel. The average value of the sand and gravel exports in 2009 was $53 per metric ton; this was down from $57 per metric ton in 2008. These values may have been relatively high because some higher grade sand and gravel, such as industrial sand and gravel, was being misclassified as construction sand and gravel.

In 2009, imports of construction sand and gravel decreased by about 45% to 2.98 Mt, and the value decreased by about 42% to $66.1 million (table 13). Canada was the leading source of imported construction sand and gravel, with 85% of the total. Mexico supplied about 8% of the imports, and The Bahamas supplied about 3%. The average unit value of the sand and gravel imports in 2009 was $22.14 per metric ton, up from $20.93 per metric ton in 2008.

Outlook

Consumption of construction sand and gravel in 2010 was expected to be about equal to that of 2009. Continuing weak demand from most construction segments and reduced revenues to and funding for governmental agencies and programs were expected to result in little or no growth in sand and gravel consumption in 2010. Data from the 2010 USGS quarterly survey of U.S. aggregates producers indicate about a 2% decrease in sales of sand and gravel compared with those of the 2009, based on a limited sample of sand and gravel producers surveyed in the United States. However, the same report indicated improving production and consumption of construction sand and gravel in the later months of 2010.

Mostly owing to weakened demand, growth in construction sand and gravel prices slowed in 2009, and a low single digit increase in pricing were expected for 2010. Improving but still historically low sales in the housing market and fluctuating fuel costs could keep some upward pressures on sand and gravel prices. Larger price increases are more likely to continue in and near metropolitan areas because, as nearby resources are used up, more aggregates will be transported from distant sources with the accompanying extra fuel cost.

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TABLE 1

SALIENT U.S. CONSTRUCTION SAND AND GRAVEL STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2005	2006	2007	2008	2009
Sold or used by producers:[2]					
Quantity	1,280,000	1,340,000 r	1,250,000 r	1,060,000 r	836,000
Value	7,520,000 r	8,650,000 r	8,820,000 r	7,900,000 r	6,330,000
Recycle:[3]					
Quantity	14,400	15,400	20,100	29,100 r	29,000
Value	99,200	111,000	150,000	252,000 r	272,000
Exports:					
Quantity	519	515	365	392	439
Value	28,200	24,100	28,700	22,400	23,100
Imports:					
Quantity	7,160	4,960	4,420	5,430	2,980
Value	86,800	94,100	87,700	114,000	66,100

r Revised.

[1] Data are rounded to no more than three significant digits.

[2] Puerto Rico is excluded from all sand and gravel statistics.

[3] Asphalt and portland cement concrete recycled by construction, demolition, and aggregate mining companies.

TABLE 2

CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY GEOGRAPHIC DIVISION[1]

	2008				2009			
Region/division	Quantity r (thousand metric tons)	Percentage of total	Value (thousands)	Percentage of total	Quantity (thousand metric tons)	Percentage of total	Value (thousands)	Percentage of total
Northeast:								
New England	43,900 r	4.2 r	$360,000	4.6	37,400	4.6	$321,000	5.1
Middle Atlantic	64,100 r	6.1	544,000 r	6.9	56,100	6.7	497,000	7.9
Midwest:								
East North Central	165,000 r	15.6	950,000 r	12.0	132,000	15.8	804,000	12.7
West North Central	112,000 r	10.6 r	606,000 r	7.7 r	102,000	12.2	551,000	8.7
South:								
South Atlantic	80,400 r	7.6	626,000 r	7.9 r	53,000	6.3	452,000	7.1
East South Central	41,300 r	3.9	277,000 r	3.5	35,300	4.2	248,000	3.9
West South Central	135,000 r	12.7 r	1,020,000 r	12.9 r	111,000	13.3	871,000	13.8
West:								
Mountain	238,000 r	22.5 r	1,690,000 r	21.4 r	179,000	21.4	1,270,000	20.1
Pacific	178,000 r	16.8 r	1,820,000	23.0 r	130,000	15.5	1,310,000	20.8
Total	1,060,000 r	100	7,900,000 r	100	836,000	100	6,330,000	100

r Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 3
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

State	2008			2009		
	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value
Alabama	13,800 [r]	$87,300 [r]	$6.35 [r]	10,000	$64,800	$6.49
Alaska	11,400 [r]	84,800 [r]	7.41 [r]	7,320	55,500	7.58
Arizona	67,200 [r]	562,000 [r]	8.36 [r]	40,200	357,000	8.88
Arkansas	8,800	65,100	7.40	8,980	69,800	7.78
California	111,000 [r]	1,260,000 [r]	11.39 [r]	79,200	912,000	11.52
Colorado	37,800 [r]	299,000 [r]	7.89 [r]	29,300	217,000	7.42
Connecticut	7,350 [r]	69,600 [r]	9.48 [r]	5,680	60,800	10.70
Delaware	2,550	20,600	8.09 [r]	2,080	24,500	11.80
Florida	28,200 [r]	219,000	7.78 [r]	15,600	125,000	8.01
Georgia	7,360 [r]	40,300 [r]	5.47	5,260	31,100	5.91
Hawaii	1,640 [r]	29,800 [r]	18.24 [r]	1,130	14,300	12.70
Idaho	18,800 [r]	107,000 [r]	5.71	12,900	75,000	5.82
Illinois	27,000 [r]	168,000 [r]	6.21 [r]	22,500	144,000	6.40
Indiana	23,300 [r]	139,000 [r]	5.96 [r]	18,800	100,000	5.31
Iowa	15,800 [r]	89,500 [r]	5.65 [r]	13,600	87,600	6.44
Kansas	10,500 [r]	51,600 [r]	4.93	8,580	43,300	5.04
Kentucky	7,620 [r]	41,700 [r]	5.47	7,260	39,800	5.48
Louisiana	22,900 [r]	231,000 [r]	10.09	20,600	205,000	9.92
Maine	10,200 [r]	69,100 [r]	6.79 [r]	9,090	59,300	6.52
Maryland[2]	12,000	126,000	10.47 [r]	7,980	99,200	12.43
Massachusetts	11,300 [r]	110,000 [r]	9.71 [r]	9,460	85,600	9.05
Michigan	45,100 [r]	211,000 [r]	4.67 [r]	34,600	176,000	5.09
Minnesota	34,700 [r]	227,000 [r]	6.53	30,800	188,000	6.10
Mississippi	12,800 [r]	91,400 [r]	7.15	12,700	101,000	7.97
Missouri	12,400 [r]	76,200 [r]	6.15 [r]	11,500	71,900	6.26
Montana	13,400 [r]	110,000 [r]	8.17 [r]	11,200	85,500	7.66
Nebraska	14,000 [r]	75,400 [r]	5.38 [r]	12,900	75,500	5.87
Nevada	29,500 [r]	163,000 [r]	5.52 [r]	21,400	138,000	6.44
New Hampshire	8,150 [r]	51,200 [r]	6.29	6,930	55,600	8.02
New Jersey	13,600 [r]	153,000 [r]	11.25 [r]	11,100	116,000	10.49
New Mexico	14,600 [r]	127,000 [r]	8.68 [r]	14,700	118,000	7.99
New York	34,400 [r]	260,000 [r]	7.55 [r]	31,100	266,000	8.56
North Carolina	9,770 [r]	58,800 [r]	6.01	7,570	43,000	5.68
North Dakota	12,100 [r]	39,200 [r]	3.24 [r]	14,400	47,000	3.28
Ohio	33,800 [r]	244,000 [r]	7.21 [r]	27,200	241,000	8.87
Oklahoma	14,700 [r]	95,500 [r]	6.50 [r]	11,600	68,200	5.90
Oregon	14,900 [r]	121,000 [r]	8.09 [r]	12,200	102,000	8.39
Pennsylvania	16,100 [r]	132,000 [r]	8.18 [r]	13,900	114,000	8.23
Rhode Island	2,000 [r]	27,400 [r]	13.66 [r]	1,820	23,300	12.79
South Carolina	9,660 [r]	46,500 [r]	4.81	5,900	32,900	5.57
South Dakota	12,500 [r]	48,000 [r]	3.83	10,500	37,900	3.59
Tennessee	7,180 [r]	56,200 [r]	7.83	5,360	42,800	7.98
Texas	88,300 [r]	631,000 [r]	7.14 [r]	70,000	528,000	7.54
Utah	38,900 [r]	222,000 [r]	5.72	32,400	190,000	5.86
Vermont	4,960 [r]	33,600 [r]	6.78 [r]	4,470	36,700	8.21
Virginia	10,400 [r]	111,000 [r]	10.63 [r]	8,180	93,100	11.38
Washington	39,600 [r]	326,000 [r]	8.23 [r]	29,900	230,000	7.69
West Virginia	426	3,840	9.00 [r]	410	3,480	8.49
Wisconsin	36,200 [r]	190,000 [r]	5.24 [r]	29,100	143,000	4.92
Wyoming	17,500 [r]	103,000 [r]	5.88 [r]	17,200	92,200	5.36
Total or average	1,060,000 [r]	7,900,000 [r]	7.47 [r]	836,000	6,330,000	7.57

See footnotes at end of table.

TABLE 3—Continued
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

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[r] Revised.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Includes data reported in Washington, DC.

TABLE 4
CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN THE UNITED STATES IN 2009, BY MAJOR USE[1]

Use	Quantity (thousand metric tons)	Value (thousands)	Unit value
Concrete aggregates (including concrete sand)	128,000	$1,080,000	$8.46
Plaster and gunite sands	12,500	99,100	7.90
Concrete products (blocks, bricks, pipe, decorative, etc.)	2,940	29,000	9.89
Asphaltic concrete aggregates and other bituminous mixtures	37,600	379,000	10.07
Road base and coverings	78,500	494,000	6.30
Road stabilization, cement	951	7,630	8.02
Road stabilization, lime	901	6,520	7.24
Fill	39,400	183,000	4.65
Snow and ice control	3,180	23,400	7.35
Railroad ballast	515	4,590	8.92
Roofing granules	209	4,260	20.39
Filtration	512	4,420	8.63
Golf course maintenance sand	852	8,340	9.79
Other miscellaneous uses	3,880	40,900	10.56
Unspecified:[2]			
Actual	162,000	1,280,000	7.92
Estimated	365,000	2,680,000	7.36
Total or average	836,000	6,330,000	7.57

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Reported and estimated production without a breakdown by end use.

TABLE 5
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY GEOGRAPHIC DIVISION AND MAJOR USE[1]

(Thousand metric tons and thousand dollars)

Region/division	Concrete aggregates (including concrete sand) Quantity	Concrete aggregates (including concrete sand) Value	Plaster and gunite sands Quantity	Plaster and gunite sands Value	Concrete products (blocks, bricks, pipe decorative, etc.) Quantity	Concrete products (blocks, bricks, pipe decorative, etc.) Value	Asphaltic concrete aggregates and other bituminous mixtures Quantity	Asphaltic concrete aggregates and other bituminous mixtures Value	Road base and coverings[2] Quantity	Road base and coverings[2] Value
Northeast:										
New England	3,740	36,400	106	869	111	837	1,570	17,600	3,890	30,000
Middle Atlantic	6,650	70,200	786	10,600	347	3,280	2,660	30,600	4,290	32,100
Midwest:										
East North Central	20,000	126,000	4,700	23,300	363	2,770	8,660	55,700	10,900	63,300
West North Central	12,600	78,000	1,430	8,530	501	4,580	3,130	26,600	16,800	60,800
South:										
South Atlantic	16,700	160,000	588	4,030	362	3,530	748	5,640	673	5,480
East South Central	9,170	62,100	123	894	74	989	1,540	15,400	884	6,000
West South Central	21,200	169,000	1,010	10,100	108	1,150	1,350	14,000	5,640	47,900
West:										
Mountain	15,100	128,000	1,580	13,300	54	804	7,530	83,100	23,600	150,000
Pacific	22,900	253,000	2,210	27,500	1,020	11,100	10,400	130,000	13,700	113,000
Total	129,000	1,080,000	12,500	99,100	2,940	29,000	37,600	379,000	80,300	509,000

Region/division	Fill Quantity	Fill Value	Snow and ice control Quantity	Snow and ice control Value	Railroad ballast Quantity	Railroad ballast Value	Other uses[3] Quantity	Other uses[3] Value	Total Quantity	Total Value
Northeast:										
New England	2,110	9,990	675	6,530	63	434	25,200	219,000	37,400	321,000
Middle Atlantic	3,530	17,900	1,010	6,360	104	941	36,700	325,000	56,100	497,000
Midwest:										
East North Central	9,900	41,600	771	3,440	35	255	76,800	488,000	132,000	804,000
West North Central	3,340	12,300	219	1,330	31	253	64,100	358,000	102,000	551,000
South:										
South Atlantic	3,980	13,500	13	107	--	--	29,900	260,000	53,000	452,000
East South Central	816	2,700	8	62	--	--	22,700	160,000	35,300	248,000
West South Central	5,460	21,500	21	157	35	649	76,400	606,000	111,000	871,000
West:										
Mountain	5,000	24,600	333	4,440	149	1,180	126,000	866,000	179,000	1,270,000
Pacific	5,210	38,900	133	981	99	878	74,100	739,000	130,000	1,310,000
Total	39,400	183,000	3,180	23,400	515	4,590	532,000	4,020,000	836,000	6,330,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes road and other stabilization (cement and lime).

[3] Includes reported and estimated production without a breakdown by end use.

TABLE 6A
CONSTRUCTION SAND AND GRAVEL PRODUCTION IN THE UNITED STATES IN 2009, BY SIZE OF OPERATION

Size range (metric tons)	Number of operations	Percentage of total	Quantity[1] (thousand metric tons)	Percentage of total
Less than 25,000	1,716	26.7	16,600	2.0
25,000 to 49,999	1,076	16.7	35,500	4.3
50,000 to 99,999	1,154	17.9	75,300	9.0
100,000 to 199,999	1,160	18.0	151,000	18.1
200,000 to 299,999	540	8.4	120,000	14.3
300,000 to 399,999	262	4.1	82,200	9.8
400,000 to 499,999	159	2.5	63,900	7.7
500,000 to 599,999	109	1.7	54,100	6.5
600,000 to 699,999	73	1.1	42,700	5.1
700,000 to 799,999	48	0.7	32,400	3.9
800,000 to 899,999	36	0.6	27,600	3.3
900,000 to 999,999	29	0.5	24,800	3.0
1,000,000 to 1,499,999	44	0.7	47,600	5.7
1,500,000 to 1,999,999	16	0.2	24,800	3.0
2,000,000 to 2,499,999	8	0.1	16,300	2.0
2,500,000 and more	7	0.1	21,300	2.6
Total	6,437	100	836,000	100

[1] Data are rounded to no more than three significant digits.

TABLE 6B
CONSTRUCTION SAND AND GRAVEL PRODUCTION IN THE UNITED STATES IN 2009, BY REGION AND SIZE OF OPERATION

	Northeast				Midwest			
Size range (metric tons)	Number of operations	Percentage of total	Quantity[1] (thousand metric tons)	Percentage of total	Number of operations	Percentage of total	Quantity[1] (thousand metric tons)	Percentage of total
Less than 25,000	359	34.8	3,510	3.8	595	26.8	6,070	2.6
25,000 to 49,999	182	17.6	6,020	6.4	402	18.1	13,300	5.7
50,000 to 99,999	180	17.4	11,700	12.5	439	19.8	28,500	12.2
100,000 to 199,999	163	15.8	21,300	22.7	418	18.9	54,100	23.1
200,000 to 299,999	71	6.9	15,700	16.8	163	7.4	36,300	15.5
300,000 to 399,999	39	3.8	12,100	13.0	79	3.6	24,700	10.6
400,000 to 499,999	17	1.7	7,000	7.5	35	1.6	14,000	6.0
500,000 to 599,999	4	0.4	1,930	2.1	34	1.5	16,900	7.2
600,000 to 699,999	5	0.5	2,930	3.1	18	0.8	10,400	4.5
700,000 to 799,999	2	0.2	1,380	1.5	8	0.4	5,280	2.3
800,000 to 899,999	2	0.2	1,500	1.6	9	0.4	6,840	2.9
900,000 to 999,999	4	0.4	3,430	3.7	11	0.5	9,270	4.0
1,000,000 to 1,499,999	3	0.3	3,190	3.4	6	0.3	6,690	2.9
1,500,000 to 1,999,999	--	--	--	--	--	--	--	--
2,000,000 to 2,499,999	1	0.1	1,840	2.0	1	--	1,900	0.8
2,500,000 and more	--	--	--	--	--	--	--	--
Total	1,032	100	93,500	100	2,218	100	234,000	100

	South				West			
Size range (metric tons)	Number of operations	Percentage of total	Quantity[1] (thousand metric tons)	Percentage of total	Number of operations	Percentage of total	Quantity[1] (thousand metric tons)	Percentage of total
Less than 25,000	206	19.0	1,950	1.0	556	26.4	5,020	1.6
25,000 to 49,999	123	11.4	4,050	2.0	369	17.5	12,200	3.9
50,000 to 99,999	182	16.8	12,000	6.0	353	16.8	23,000	7.5
100,000 to 199,999	223	20.6	30,200	15.1	356	16.9	45,800	14.8
200,000 to 299,999	126	11.6	27,400	13.8	180	8.6	40,400	13.1
300,000 to 399,999	62	5.7	19,800	9.9	82	3.9	25,500	8.3
400,000 to 499,999	51	4.7	20,700	10.4	56	2.7	22,200	7.2
500,000 to 599,999	34	3.1	16,800	8.4	37	1.8	18,500	6.0
600,000 to 699,999	21	1.9	12,300	6.2	29	1.4	17,000	5.5
700,000 to 799,999	19	1.8	12,900	6.5	19	0.9	12,900	4.2
800,000 to 899,999	13	1.2	10,100	5.0	12	0.6	9,230	3.0
900,000 to 999,999	3	0.3	2,610	1.3	11	0.5	9,490	3.1
1,000,000 to 1,499,999	11	1.0	12,400	6.2	24	1.1	25,400	8.2
1,500,000 to 1,999,999	6	0.6	9,680	4.9	10	0.5	15,100	4.9
2,000,000 to 2,499,999	2	0.2	4,170	2.1	4	0.2	8,390	2.7
2,500,000 and more	1	0.1	2,430	1.2	6	0.3	18,900	6.1
Total	1,083	100	199,000	100	2,104	100	309,000	100

-- Zero.

[1] Data are rounded to no more than three significant digits.

TABLE 7
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY GEOGRAPHIC DIVISION AND METHOD OF TRANSPORTATION[1]

(Thousand metric tons)

Region/division	Truck	Rail	Water	Other	Not transported	Not specified	Total
Northeast:							
New England	6,720	--	--	118	2,410	28,200	37,400
Middle Atlantic	12,400	8	--	12	1,190	42,400	56,100
Midwest:							
East North Central	33,400	129	2,890	473	4,420	90,900	132,000
West North Central	21,400	160	895	22	5,350	74,300	102,000
South:							
South Atlantic	17,700	28	192	79	724	34,300	53,000
East South Central	6,080	85	908	40	412	27,800	35,300
West South Central	21,700	317	27	8	3,880	85,200	111,000
West:							
Mountain	29,400	253	--	536	8,540	141,000	179,000
Pacific	35,400	--	1,080	1,460	6,100	85,700	130,000
Total	184,000	980	5,990	2,750	33,000	609,000	836,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 8
NUMBER OF CONSTRUCTION SAND AND GRAVEL OPERATIONS AND PROCESSING PLANTS IN THE UNITED STATES IN 2009, BY GEOGRAPHIC DIVISION

	Mining operations on land					
Region/division	Stationary	Portable	Stationary and portable	No plants or unspecified	Dredging operations	Total active operations
Northeast:						
New England	231	202	39	27	--	499
Middle Atlantic	247	188	44	31	23	533
Midwest:						
East North Central	515	409	74	47	86	1,131
West North Central	363	447	30	60	187	1,087
South:						
South Atlantic	149	74	15	48	74	360
East South Central	111	41	8	6	52	218
West South Central	241	118	22	40	84	505
West:						
Mountain	508	724	68	47	9	1,356
Pacific[1]	386	246	57	35	24	748
Total	2,751	2,449	357	341	539	6,437

-- Zero.

[1] An undetermined number of operations leased from the Bureau of Land Management in Alaska are counted as one operation.

TABLE 9
NUMBER OF CONSTRUCTION SAND AND GRAVEL OPERATIONS AND PROCESSING PLANTS IN THE UNITED STATES IN 2009, BY STATE

	Mining operations on land					
State	Stationary	Portable	Stationary and portable	No plants or unspecified	Dredging operations	Total active operations
Alabama	38	11	1	5	15	70
Alaska[1]	32	22	2	4	5	65
Arizona	89	112	15	3	--	219
Arkansas	28	20	4	1	4	57
California	211	93	24	7	9	344
Colorado	98	140	5	6	7	256
Connecticut	33	24	9	--	--	66
Delaware	5	--	--	2	4	11
Florida	31	9	--	7	16	63
Georgia	17	6	3	--	19	45
Hawaii	18	6	2	--	--	26
Idaho	47	95	4	14	2	162
Illinois	66	16	7	3	27	119
Indiana	70	35	12	3	14	134
Iowa	40	73	5	1	25	144
Kansas	26	40	3	10	39	118
Kentucky	9	4	2	1	9	25
Louisiana	45	15	1	12	37	110
Maine	61	70	8	13	--	152
Maryland	21	1	2	10	4	38
Massachusetts	64	21	2	2	--	89
Michigan	131	154	31	19	14	349
Minnesota	136	156	15	19	5	331
Mississippi	45	17	--	--	18	80
Missouri	36	8	2	--	28	74
Montana	62	84	7	6	--	159
Nebraska	36	17	1	5	89	148
Nevada	56	39	5	4	--	104
New Hampshire	33	41	9	4	--	87
New Jersey	31	6	4	3	12	56
New Mexico	58	52	8	3	--	121
New York	158	157	29	23	6	373
North Carolina	38	23	7	13	15	96
North Dakota	47	77	2	3	--	129
Ohio	102	51	11	4	30	198
Oklahoma	30	14	--	8	24	76
Oregon	38	43	9	9	3	102
Pennsylvania	58	25	11	5	5	104
Rhode Island	8	3	4	1	--	16
South Carolina	13	17	--	3	12	45
South Dakota	42	76	2	22	1	143
Tennessee	19	9	5	--	10	43
Texas	138	69	17	19	19	262
Utah	69	99	20	1	--	189
Vermont	32	43	7	7	--	89
Virginia	21	16	3	13	4	57
Washington	87	82	20	15	7	211
West Virginia	3	2	--	--	--	5

See footnotes at end of table.

TABLE 9—Continued

NUMBER OF CONSTRUCTION SAND AND GRAVEL OPERATIONS AND PROCESSING PLANTS IN THE UNITED STATES IN 2009, BY STATE

	Mining operations on land					
State	Stationary	Portable	Stationary and portable	No plants or unspecified	Dredging operations	Total active operations
Wisconsin	146	153	13	18	1	331
Wyoming	29	103	4	10	--	146
Total	2,751	2,449	357	341	539	6,437

-- Zero.

[1] An undetermined number of operations leased from the Bureau of Land Management in Alaska are counted as one operation.

TABLE 10

RECYCLED ASPHALT SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1, 2]

State	2008 Quantity (thousand metric tons)	2008 Value (thousands)	2008 Unit value	2009 Quantity (thousand metric tons)	2009 Value (thousands)	2009 Unit value
Alabama	112	$2,090	$18.62	126	$2,520	$20.02
Alaska	105[r]	1,770[r]	16.81[r]	57	1,200	21.02
Arizona	137	820	5.99	227	1,370	6.02
Arkansas	--	--	--	85	908	10.68
California	1,550[r]	12,500[r]	8.11[r]	1,700	11,600	6.82
Colorado	514[r]	4,950	9.62[r]	362	4,050	11.18
Connecticut	133	530	3.98	124	517	4.17
Delaware	2	35	17.50	2	35	17.50
Florida	415	5,980	14.40[r]	903	12,300	13.66
Georgia	96	2,770	28.89[r]	196	4,280	21.83
Hawaii	73	1,040	14.25	73	1,030	14.16
Idaho	88	659	7.49	94	587	6.24
Illinois	843	8,210	9.74	1,460	12,500	8.57
Indiana	172[r]	1,640[r]	9.54[r]	225	1,870	8.30
Iowa	37	290	7.84	26	209	8.04
Kansas	1,140	30,900	27.02[r]	1,290	33,200	25.74
Kentucky	49	928	18.94	49	928	18.94
Louisiana	147	908	6.18	134	757	5.65
Maine	176	1,380	7.82[r]	139	1,130	8.14
Maryland	194	999	5.15	145	702	4.84
Massachusetts	305	1,960	6.42[r]	287	2,410	8.40
Michigan	315	1,540	4.88[r]	532	3,010	5.67
Minnesota	805[r]	7,240[r]	8.99[r]	528	5,430	10.29
Mississippi	81	1,570	19.35[r]	136	1,780	13.09
Missouri	208	922	4.43	164	693	4.23
Montana	75	338	4.51	8	89	11.13
Nebraska	32	745	23.28	83	1,090	13.14
Nevada	49	275	5.61	275	1,500	5.46
New Hampshire	256	3,420	13.34[r]	296	3,480	11.74
New Jersey	154	1,120	7.24[r]	155	1,350	8.70
New Mexico	195	1,410	7.25[r]	771	9,850	12.78
New York	256	1,630	6.36[r]	380	2,840	7.47
North Carolina	318	2,300	7.23	874	7,850	8.98
North Dakota	28	126	4.50	40	450	11.25
Ohio	68	249	3.66	179	1,090	6.10
Oklahoma	103	1,540	14.98[r]	118	1,570	13.33
Oregon	235[r]	1,940[r]	8.26[r]	216	1,580	7.29
Pennsylvania	1,120	10,700	9.54[r]	1,020	10,100	9.97
Rhode Island	69	920	13.33	66	202	3.06
South Carolina	191[r]	4,010[r]	21.02[r]	204	4,420	21.65
South Dakota	80	446	5.58	120	751	6.26
Tennessee	54	409	7.57	197	1,450	7.36
Texas	700	7,280	10.40	616	4,650	7.54
Utah	431[r]	2,440[r]	5.66[r]	234	1,560	6.67
Vermont	30	242	8.07	28	425	15.18
Virginia	955	1,310[r]	1.37[r]	233	2,980	12.79
Washington	195	1,080	5.53[r]	168	499	2.97
West Virginia	--	--	--	--	--	--
Wisconsin	747	4,980	6.67	624	4,290	6.87

See footnotes at end of table.

TABLE 10—Continued

RECYCLED ASPHALT SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1, 2]

State	2008 Quantity (thousand metric tons)	2008 Value (thousands)	2008 Unit value	2009 Quantity (thousand metric tons)	2009 Value (thousands)	2009 Unit value
Wyoming	29	$360	$12.41	14	$205	$14.64
U.S. total or average	14,100 r	141,000 r	10.02 r	16,000	169,000	10.60
Territory						
Puerto Rico	45	169	3.75	45	169	3.75
Grand total or average	14,100 r	141,000 r	10.00 r	16,000	170,000	10.58

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Includes construction and demolition companies that do not mine virgin aggregates.

TABLE 11

RECYCLED CONCRETE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1, 2]

State	2008			2009		
	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value
Alabama	45	$317	$7.04	51	$377	$7.39
Alaska	64 [r]	304 [r]	4.75 [r]	25	124	4.96
Arizona	192	1,050	5.48 [r]	70	485	6.93
Arkansas	--	--	--	42	193	4.60
California	2,270 [r]	17,000 [r]	7.51 [r]	1,770	14,300	8.07
Colorado	767	5,010	6.53	644	4,500	6.99
Connecticut	90	310	3.44	41	328	8.00
Delaware	7	75	10.71	7	75	10.71
Florida	233	3,640	15.63 [r]	424	4,830	11.40
Georgia	10	57	5.70	83	274	3.30
Hawaii	23	252	10.96	22	215	9.77
Idaho	27	190	7.04	32	192	6.00
Illinois	1,410	10,600	7.55 [r]	1,180	8,820	7.51
Indiana	105	717	6.83	139	752	5.41
Iowa	34	248	7.29	28	238	8.50
Kansas	25	311	12.44	297	2,230	7.51
Kentucky	440	4,370	9.93	441	4,370	9.92
Louisiana	29	434	14.97	7	71	10.14
Maine	28	163	5.82	39	294	7.54
Maryland	254	1,160	4.55 [r]	389	2,030	5.21
Massachusetts	300	2,260	7.55 [r]	192	1,610	8.39
Michigan	520	2,520	4.85	1,010	7,180	7.13
Minnesota	1,290	6,850	5.30 [r]	765	4,700	6.14
Mississippi	71	1,540	21.75 [r]	71	1,550	21.82
Missouri	1	2	2.00	1	2	2.00
Montana	81	378	4.67	20	155	7.75
Nebraska	98	877	8.95	122	1,120	9.19
Nevada	151	804	5.32	93	560	6.02
New Hampshire	11	93	8.45	12	109	9.08
New Jersey	381	2,740	7.19	583	4,730	8.11
New Mexico	171	1,840	10.74 [r]	1	2	2.00
New York	399 [r]	2,850 [r]	7.15 [r]	338	2,620	7.75
North Carolina	139	1,810	13.03 [r]	143	1,850	12.94
North Dakota	9	61	6.78	17	187	11.00
Ohio	225	1,590	7.05 [r]	337	2,230	6.61
Oklahoma	225	2,940	13.08 [r]	224	2,940	13.13
Oregon	80	747	9.34	101	882	8.73
Pennsylvania	429	2,350	5.48	420	2,450	5.82
Rhode Island	32	301	9.41	127	176	1.39
South Carolina	235	3,400	14.46 [r]	216	3,630	16.81
South Dakota	158	699	4.42	109	534	4.90
Tennessee	--	--	--	25	149	5.96
Texas	1,660	12,400	7.49 [r]	859	6,750	7.86
Utah	381 [r]	3,060 [r]	8.04 [r]	223	1,890	8.48
Vermont	16	81	5.06	22	102	4.64
Virginia	588	5,440	9.25	631	5,680	9.01
Washington	407	2,220	5.46 [r]	216	1,330	6.14
West Virginia	--	--	--	--	--	--
Wisconsin	645	3,580	5.55	369	1,940	5.24
Wyoming	236	1,640	6.94 [r]	59	339	5.75
U.S. total or average	15,000 [r]	111,000 [r]	7.43	13,000	102,000	7.83
Territory						
Puerto Rico	--	--	--	--	--	--
Grand total or average	15,000 [r]	111,000 [r]	7.43 [r]	13,000	102,000	7.83

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Includes construction and demolition companies that do not mine virgin aggregates.

TABLE 12
U.S. EXPORTS OF CONSTRUCTION SAND AND GRAVEL IN 2009, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

	Sand		Gravel	
Country or territory	Quantity	Value, f.a.s.[2]	Quantity	Value, f.a.s.[2]
North America:				
Bahamas, The	7	522	17	635
Canada	20	2,150	327	2,800
Mexico	2	439	1	25
Other	18	1,290	8	231
Total	47	4,400	353	3,690
South America	3	2,320	1	60
Europe	4	3,310	3	170
Asia	3	1,920	1	32
Oceania	(3)	119	--	--
Middle East	19	5,820	3	88
Africa, other	4	1,140	(3)	13
Grand total	79	19,000	360	4,050

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship. Value of material at U.S. port of export; based on transaction price, including all charges incurred in placing material alongside ship.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF CONSTRUCTION SAND AND GRAVEL, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2008		2009	
Country or territory	Quantity	Value, c.i.f.[2]	Quantity	Value, c.i.f.[2]
Antigua and Barbuda	--	--	4	94
Australia	21	1,560	2	604
Bahamas, The	462	5,600	81	1,490
Canada	4,500	86,800	2,540	47,500
China	17	3,750	19	2,580
Germany	25	253	(3)	327
Japan	(3)	458	(3)	154
Mexico	318	5,500	228	5,680
New Zealand	11	1,990	4	755
Peru	3	690	3	683
Philippines	1	212	(3)	70
Other	66	6,740	95	6,120
Total	5,430	114,000	2,980	66,100

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight. Value of material at U.S. port of entry; based on purchase price and includes all charges (except U.S. import duties) in bringing material from foreign country to alongside carrier.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 14

THE TOP 100 PRODUCERS OF CONSTRUCTION SAND & GRAVEL IN THE UNITED STATES IN 2009[1]

2009 Rank	2008 Rank	Company	2009 Rank	2008 Rank	Company
1	2	Oldcastle Materials, Inc.	51	84	Sundre Sand & Gravel, Inc.
2	1	CEMEX S.A.B. de C.V.	52	69	Amboy Aggregates
3	4	Vulcan Materials Co.	53	56	Eagle Materials Inc.
4	3	Lehigh Hanson, Inc.	54	61	Snyder Associated Cos., Inc.
5	6	MDU Resources Group, Inc.	55	34	Holliday Rock Products Corp.
6	5	Holcim Group/Aggregate Industries Mgmt., Inc.	56	73	Standard Gravel Co., Inc.
7	13	Mitsubishi Materials Corp.	57	—	Blain Sand & Gravel, Inc.
8	7	Bureau of Land Management	58	63	Chandler Aggregates, Inc.
9	10	Lafarge North America, Inc.	59	65	Lakeview Sand & Gravel Co.
10	9	Martin Marietta Aggregates	60	52	U.S. Concrete, Inc.
11	11	Fisher Industries	61	82	Southway Construction Co., Inc.
12	8	Granite Construction, Inc.	62	79	FST Sand & Gravel, Inc.
13	15	Clyde Cos., Inc.	63	49	Rieth-Riley Construction Co., Inc.
14	12	CalPortland Co.	64	51	Salt River Pima-Maricopa Indian Community
15	18	Trinity Industries, Inc.	65	70	Aggregate Resources, Inc.
16	14	A. Teichert & Son, Inc.	66	81	Pacific Clay Products, Inc.
17	16	Colas Inc.	67	59	Boral USA
18	53	Las Vegas Paving Corp.	68	60	Southwest Rock Products, LLC
19	21	Fordyce Ltd.	69	41	The Olen Corp.
20	20	Nugent Sand Co.	70	—	Fred Weber, Inc.
21	19	Gila River Indian Community	71	76	Wood Resources Corp.
22	17	Texas Industries, Inc.	72	66	Watson Gravel, Inc.
23	25	York Building Products Co.	73	74	Grand Rapids Gravel Co.
24	26	Lyman-Richey Sand & Gravel Co.	74	71	Wright Materials, Inc.
25	28	Mathy Construction Co.	75	93	M.R. Tanner Mining, Inc.
26	40	Mulzer Crushed Stone, Inc.	76	77	Hilltop Basic Resources, Inc.
27	36	Ash Grove Cement Co.	77	—	Waste Management, Inc.
28	39	Southern Aggregates, LLC	78	—	Close Construction Co., Inc.
29	33	R.E. Janes Gravel Co .	79	85	Johnson Sand & Gravel, Inc.
30	44	McMurry Ready Mix Co.	80	—	Frank Bryan, Inc.
31	30	Eucon Corp.	81	57	Memphis Stone & Gravel Co.
32	32	All American Asphalt Co.	82	47	Ennstone Inc.
33	35	Harper Investments, Inc.	83	—	James Construction Group
34	22	Edw. C. Levy Co.	84	75	Heritage Group
35	53	Central Specialties, Inc.	85	83	Nebco, Inc.
36	24	E.R. Jahna Industries, Inc.	86	—	Clemente Material, Inc.
37	23	Lattimore Properties, Inc.	87	—	Tri-Con Materials, Inc.
38	38	L.G. Everist, Inc.	88	62	Continental Materials Corp.
39	—	Quikrete Companies, Inc.	89	80	Hall-Irwin Corp.
40	87	Capital Sand Co., Inc.	90	—	Roanoke Sand & Gravel Corp.
41	37	Miles Sand & Gravel Co.	91	—	Wm. D. Scepaniak, Inc.
42	78	FNF Mining, Inc.	92	99	Ready Mix USA, Inc.
43	58	Jobe Materials, LP	93	—	Michels Corporation
44	50	Dan Gernatt Gravel Products, Inc.	94	86	LS Sand & Gravel Ltd.
45	54	New Enterprises Stone & Lime Co., Inc.	95	—	A. Lindberg & Sons, Inc.
46	43	Thelen Sand & Gravel, Inc.	96	—	St. Charles Sand Co.
47	68	Dolese Bros. Co.	97	—	Bowes Construction, Inc.
48	45	Multisources Ltd.	98	—	J.J. Ferguson Sand & Gravel Co.
49	64	BSC Holding, Inc.	99	—	LeGrand Johnson Construction Co.
50	48	Irving Materials, Inc.	100	—	Strata Corp.

— Not in the top 100 producers of crushed stone in the United States in 2008.

[1] In descending order of tonnage produced.

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SELENIUM AND TELLURIUM

By Micheal W. George

Domestic survey data and tables were prepared by Maria Arguelles, statistical assistant, and the world production tables were prepared by Glenn J. Wallace, international data coordinator.

In 2009, the average U.S. dealers' prices for commercial-grade selenium and tellurium lump and powder declined from those of yearend 2008. Estimated global consumption for both metals also declined. One copper refinery in Texas reported domestic production of primary refined selenium and tellurium. Domestic production of selenium and tellurium decreased in 2009 as did estimates of global production.

Selenium and tellurium were recovered as byproducts of nonferrous metal mining, mostly from the anode slimes associated with electrolytic refining of copper. Selenium and tellurium were also recovered as byproducts from gold, lead, nickel, platinum, and zinc mining.

In a 2006 survey of 56 worldwide electrolytic copper refiners, 52 and 45 plants, respectively, reported selenium and tellurium in their anode slimes. The selenium-containing slimes averaged 7% selenium by weight, with a few containing as much as 25% selenium. Tellurium concentrations were generally lower and averaged 2% (Moats and others, 2007, p. 202–241).

Selenium and tellurium can also be recovered economically from industrial scrap and chemical process residues. Obsolete and damaged photoreceptor drums from plain paper copy machines have been shipped by manufacturers to refineries for recovery of selenium and tellurium metal. The supply of old drums, however, has declined in recent years and now appears to be nearly exhausted.

Production

Asarco LLC's (Tucson, AZ) copper refinery in Amarillo, TX, was the only U.S. producer of refined selenium and tellurium. One copper refinery produced and exported semirefined material containing 90% selenium plus tellurium for toll-refining in Asia. Two other refineries generated selenium- and tellurium-containing slimes that were exported for processing. Most of the selenium and tellurium contained in domestic anode slimes came from copper ores in Arizona and Utah. One refinery processed anodes imported from Canada. Domestic production of selenium and tellurium decreased in 2009 compared with that of 2008.

Asarco had operated under bankruptcy protection since August 2005. In 2009, Grupo Mexico S.A.B. de C.V. (Mexico City, Mexico) (the parent company of Asarco) regained control of the Asarco refinery and on December 9, Asarco was fully released from its legal contingencies and exited bankruptcy protection (Grupo Mexico S.A.B. de C.V., 2010, p. 2).

With the higher price of tellurium that persisted during 2007–09 and projected increases in demand, tellurium was increasingly viewed as a valuable byproduct. This helped stimulate exploration for gold-telluride ores, including some early stage projects in the Western United States.

Consumption

Selenium.—In 2009, world consumption of selenium was estimated to be lower than revised 2008 consumption data owing to the global economic downturn. Compared with revised 2008 consumption levels, consumption of selenium was estimated to be down by 10% to 20% in the glass industry, by 15% in the electrolytic manganese industry, and by 40% in the animal feed and agriculture industry. Selenium used in chemical and pigments applications in 2009 was down slightly compared with that in 2008. Other metallurgical, electronic, and other applications in 2009 were estimated to be higher compared with 2008 consumption levels (Metal-Pages, 2009g). The estimated global distribution of consumption of selenium by application was metallurgy, 35%; glass manufacturing, 25%; agriculture, 10%; chemicals and pigments, 10%; electronics, 10%; and other, 10%. This represents a significant shift in the demand pattern; glass manufacturing was the leading end use for selenium for more than a decade.

The main use for selenium in metallurgical end uses was for the production of electrolytic manganese in China where selenium dioxide (SeO_2) was substituted for sulfur dioxide to reduce the power required to operate electrolytic cells. In 2009, demand for selenium by electrolytic manganese metal producers in China decreased compared with that in 2008 owing to decreased consumption of electrolytic manganese metal by steel producers. About 2 kilograms of SeO_2 were used per metric ton of electrolytic manganese metal produced (Selenium-Tellurium Development Association, 2002; Metal-Pages, 2009c).

Metallurgical-grade selenium was used as an additive to cast iron, copper, lead, and steel alloys to improve machinability and casting and forming properties. In the United States, selenium was used as an alloy with bismuth to substitute for lead in plumbing fixtures in response to requirements of the Safe Drinking Water Act Amendments of 1996 (Public Law 104–182) to reduce lead in potable water supplies. In lead-acid storage batteries, the addition of a small amount, about 0.02% by weight, of selenium to low-antimony lead alloys used in the support grids improves the casting and mechanical properties of the alloy.

Selenium was used to decolorize the green tint caused by iron impurities in container glass and other soda-lime silica glass. It was also used as a colorant in art and other glass, such as that used in traffic lights, and in architectural plate and automobile glass to reduce solar heat transmission through the glass.

Selenium, an essential micronutrient for animal and human health, was added to fertilizer used to grow crops for animal and human consumption. This practice was more common outside the United States, in countries with selenium-poor soils, such as Australia and China.

Chemical and pigment uses of selenium include industrial and pharmaceutical applications. Selenium's principal pharmaceutical use was in shampoo to control dandruff and dermatitis and as an antifungal agent. Cadmium sulfoselenide compounds were used as pigments in ceramics, glazes, paints, and plastics, but because of the relatively high cost and the toxicity of cadmium-based pigments, their use was generally restricted to applications where they were uniquely suited. Additionally, selenium was used in catalysts to enhance selective oxidation in plating solutions to improve appearance and durability, in blasting caps and gun bluing, in digital x-ray detectors, and in zinc selenide for infrared windows in carbon dioxide lasers.

Although conventional silicon-based cells remained the dominant photovoltaic (PV) technology, thin-film PV cells production continued to increase in 2009. Three major types of thin-film PV cells were in commercial production—amorphous silicon and thin-silicon, cadmium telluride (CdTe), and copper indium gallium diselenide (CIGS). Several companies announced plans to expand production of nonsilicon-based solar cells within the next several years. It was projected that CIGS production would reach almost 1 gigawatt (GW) by 2010 and 2.5 GW by 2012. Recent advancements in CIGS thin films have reduced production costs, improved performance, and reduced the environmental impact of production. In 2009, more than 40 companies were involved in the development of CIGS products. Commercial CIGS solar cells have achieved conversion efficiencies of 12% using 0.01% of the material contained in crystalline silicon-based solar cells. It was estimated that to generate 1 GW of power by CIGS solar cell would require about 55 metric tons (t) of selenium, 20 t of indium, 15 t of copper, and 4 t of gallium (Kanellos, 2008; Kho, 2008; Ullal, 2008; Metal-Pages, 2009d, h).

Tellurium.—World demand for tellurium was estimated to have decreased in 2009. The leading use for tellurium was as a metallurgical alloying element. Tellurium was used in steel as a free-machining additive, in copper to improve machinability while not reducing conductivity, in lead to improve resistance to vibration and fatigue, in cast iron to help control the depth of chill, and in malleable iron as a carbide stabilizer. Owing to recent higher prices, many steel and nonferrous metals producers have reduced consumption and found substitutes for tellurium.

Consumption in chemical, catalysts, and other uses, the next largest end-use category, declined owing to the recent increases in price. Tellurium was used as a vulcanizing agent and as an accelerator in the processing of rubber and in catalysts for synthetic fiber production. Other applications included the use of tellurium in blasting caps and as a pigment to produce blue and brown colors in ceramics and glass.

High-purity tellurium was used in alloys for electronics applications, such as thermal imaging, thermoelectric, phase-change memory, and photoelectric devices. Consumption of tellurium in these applications was estimated to have decreased in 2009 because of the global economic downturn.

Mercury-cadmium-telluride was used in thermal-imaging devices to convert the raw image into a crisp picture on the screen, for infrared sensors, and for heat-seeking missiles. Semiconducting bismuth telluride was used in thermoelectric cooling devices employed in electronics and consumer products. These devices consist of a series of couples of semiconducting materials which, when connected to a direct current, cause one side of the thermo element to cool while the other side heats. Thermoelectric coolers were most commonly used in electronics and military applications, such as the cooling of infrared detectors, integrated circuits, laser diodes, and medical instrumentation. The devices were also used in high-end automobile car seats to cool seats on hot days. However, with the global economic downturn in late 2008, tellurium consumption in thermoelectric consumer goods decreased in 2009.

During 2009, the CdTe thin-film PV cell industry increased investments in research and capacity. First Solar Inc. (Phoenix, AZ), the global leader in CdTe production, had plants in Germany, Ohio, and, Malaysia. In 2009, estimated global production for First Solar rose to 1,230 megawatts (MW), from 716 MW in 2008 owing to expansion at its new plant in Malaysia. In the fourth quarter 2009, First Solar reported that efficiency of its CdTe cells reached 11.1%. In April, Abound Solar Inc. (Fort Collins, CO) opened its first full-scale CdTe solar cell production facility in Longmont, CO, that had a capacity of 200 MW. Other manufacturers that were planning to produce CdTe solar cells were Calyxo GmbH (Bitterfeld-Wolfen, Germany) and PrimeStar Solar Inc. (Arvada, CO). 5N Plus Inc. (Saint-Laurent, Quebec, Canada) was the principal supplier of high-purity cadmium and tellurium to the thin-film industry. The thin-film industry accounted for three-quarters of 5N Plus' business (Kho, 2008; Ullal, 2008; Abound Solar Inc., 2009; 5N Plus Inc., 2010, p. 6; First Solar Inc., 2010, p. 1-10).

Prices

The Platts Metals Week annual average New York dealer price for selenium was $23.07 per pound in 2009 and was 26% lower than the annual average price in 2008. The price remained about $20 per pound for the first 7 months of 2009, down from the yearend 2008 price of $23 per pound. Some analysts thought that after peaking at more than $40 per pound in March 2008, the downward-trending price was caused by an oversupply that developed in 2008 because of decreased demand and continued into the first half of 2009. The price rose in August because of increased demand from glass and ceramics production in India and electrolytic manganese metal production in China and finished the year at $29 per pound (Metals Bulletin, 2009; Poole, 2009; Roskill's Letters from Japan, 2009).

The United Kingdom price for lump and powder, 99.95%-pure tellurium, as published in Mining Journal, started 2009 at $160 to $190 per kilogram. The price range decreased to $125 to $170 per kilogram on February 23 and again decreased to $110 to $150 per kilogram in September when Mining Journal discontinued publishing tellurium prices. On November 3, Metal-Pages started publishing a Rotterdam 99.99%-pure tellurium price range, from $135 to $160 per kilogram. The price range increased to $145 to $170 per kilogram on December 17 and remained at this level for the rest of the year.

Foreign Trade

Exports of selenium materials in 2009 increased by 13% compared with those of 2008. In descending order, Hong Kong, China, Australia, Germany, the Republic of Korea, and Sweden accounted for 88% of selenium exports in 2009 (table 2).

In 2009, imports of selenium (SeO_2 and selenium unwrought and waste and scrap) decreased by 49% to 263 t, compared with 2008 imports (table 3). Germany, Canada, Mexico, Belgium, the Philippines, Japan, China, and the United Kingdom, in descending order, accounted for 99% of the imports of selenium metal and SeO_2 into the United States in 2009.

Imports of unwrought tellurium and tellurium waste and scrap decreased by 18% in 2009 compared with the alltime high imports in 2008. The leading suppliers, in descending order, China, Canada, the Philippines, Russia, Belgium, Japan, and Mexico, accounted for 99% of the total imports of tellurium metal into the United States (table 5). The annual average value of imports in 2009 was $134.95 per kilogram of tellurium was high by historic standards but was lower than the alltime high of $174.21 per kilogram in 2008.

In 2009, tellurium exports fell to 8 t, an 84% decrease from 50 t in 2008. The main destinations, in descending order, were Germany, China, Hong Kong, the United Kingdom, and Taiwan, and accounted for 93% of total tellurium exports (table 4). Despite lower prices for tellurium metal, the annual average value of exports of tellurium in 2009 was $148.34 per kilogram, which was higher than the 2008 value of $60.57 per kilogram but lower than the alltime high of $200.07 per kilogram in 2006. In 2009, much of the stockpiles of low-value tellurium scrap were depleted owing to increased exports of scrap in 2008 because of the higher price that year.

World Review

Global selenium and tellurium output cannot be easily determined because not all companies or countries report production and because trade in scrap and semirefined products may be included in selenium trade data.

In 2009, refinery production of selenium based on data from a select few countries increased slightly to 2,280 t (table 6). Total world production was estimated to be about 3,000 to 3,500 metric tons per year (t/yr) of selenium and 450 to 500 t/yr of tellurium. Based on global copper refinery data (Moats and others, 2007, p. 202–241), the U.S. Geological Survey estimated that just copper anode slimes in 2006 contained 4,600 t and 1,200 t of selenium and tellurium, respectively.

Canada.—In 2009, the Canadian Government estimated selenium production to be 173 t, up by 11% compared with that of 2008. Tellurium production in Canada was 16 t, down by 19% from that of 2008 (Natural Resources Canada, 2010).

China.—In 2009, China was the leading consumer and a significant producer of selenium. China still depended, however, on imports for most of its selenium needs and imported 1,400 t of selenium products in 2008, a 3% increase compared with 2008 imports. China's consumption was estimated to be 1,500 to 2,000 t/yr, with electrolytic manganese production consuming about 1,000 t/yr and ceramics and glassmaking consuming 350 t/yr. In 2009, the country had about 400 t/yr of refined selenium capacity, but this was expected to increase to 600 t/yr of selenium when new production techniques are implemented (Metal-Pages, 2009b).

Apollo Solar Energy, Inc. (Chengdu, Sichuan Province) was investigating the possibility of starting up two mines where the primary product is tellurium. The company announced that the indicated and inferred resources for the Dashuigou project were 30,200 t of ore grading 1.09% tellurium and containing 328 t of tellurium, and the Majiagou project resources were 13,400 t of ore grading 3.26% tellurium and containing 437 t of tellurium (Metal-Pages, 2009e).

China planned to impose a new 2% import tax on tellurium imports in 2010. Sources suggested that the tax would have little influence on the price of tellurium because of the relatively small amount of tellurium imported. The import tariffs for selenium were to be lowered to 2% in 2010 from 3% in 2009 (Metal-Pages, 2009a).

Japan.—The major producers of selenium and tellurium were Mitsubishi Materials Corp.; Mitsui Metal Mining and Smelting Co., Ltd.; Nikko Metals Co., Ltd.; Nippon Rare Metals, Inc.; Shinko Chemicals Co., Ltd.; and Sumitomo Metal Mining Co., Ltd. In 2009, selenium production was estimated to be 780 t, an increase of 3% compared with that of 2008. Japanese principle production of tellurium was as a byproduct of copper refining, and the majority was consumed in the Japanese steel industry. In 2009, stocks of selenium decreased to 116 t, a 27% decline compared with stocks at the end of 2008 (Roskill's Letters from Japan, 2010).

Mexico.—In 2009, Southern Copper Corp. (Phoenix, AZ) operated the La Caridad precious metals plant in the State of Sonora, which had a capacity to produce 342 kilograms per day of selenium. Production in 2009 likely declined owing to lower production of refined copper (Southern Copper Corp., 2010, p. 72).

Peru.—Southern Copper produced selenium at its Ilo refinery in the southern part of Peru. In 2009, selenium production was 56,000 kilograms, up by 27% compared with that of 2008 (Southern Copper Corp., 2010, p. 47).

Poland.—Copper producer KGHM Polska Miedź S.A. (Lubin) produced selenium at its precious metal plant at the Glogów smelter from anode slimes generated at its Glogów and Legnica copper refineries (KGHM Polska Miedź S.A., 2010).

Russia.—The major producers of selenium were OSJC MMC Norilsk Nickel (Moscow), Kyshtymsky Electrolyte Copper JSC (Ekateinburg), and Uralelectromed JCS (Verkhnaya Pyshma), with Norilsk and Uralelectromed also producing tellurium. Annual production was estimated to be 140 t and 34 t of selenium and tellurium, respectively, with annual consumption estimated to be 55 t and 10 t of selenium and tellurium, respectively (Metal-Pages, 2009f).

Outlook

The supply of selenium and tellurium is directly affected by the production of the principal product from which it is derived—copper—and to a lesser extent, by the production of gold, lead, nickel, or zinc produced from sulfide ores. Since global refined production of copper was projected to remain relatively unchanged, production of selenium and tellurium also was expected to remain about the same in 2010. Increased recovery rates at copper refiners could increase selenium and tellurium supply, and longer term investments in gold-tellurium deposits and other sources of tellurium could supply growth exceeding that of copper production growth. Although increased environmental regulation and prices have encouraged the recycling of electronic scrap, recovery of selenium and tellurium has been declining during the past several years owing to the reduction in available scrap selenium- and tellurium-based copier drums. However, many high-grade tellurium producers and users were recovering much of the manufacturing scrap from the production of consumable goods. Also, solar-cell recycling plants have been built in the United States and around the world that would capture selenium and tellurium from CIGS and CdTe cells.

Demand from China for selenium was expected to increase owing to increased demand for agriculture and from the electrolytic manganese metal industry. Global demand for selenium from glass and solar cell manufacturers will probably increase as there are few substitutes in glass manufacturing, and the expansion of solar-cell production was expected to continue.

In 2010, tellurium consumption was expected to increase, chiefly from increased electronics and solar-cell production. As the technologies for these uses, especially solar-cells and thermoelectronics, continue to advance, manufacturers likely will find ways to reduce unit consumption through efficiency, recycling, and thrifting. Consumption for metallurgical alloying and chemicals was expected to decrease as the cost of tellurium continues to rise; producers of low-value products were expected to find substitutes.

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TABLE 1

SALIENT SELENIUM AND TELLURIUM STATISTICS[1]

(Kilograms, contained metal, unless otherwise specified)

	2005	2006	2007	2008	2009
Selenium:					
United States:					
Production, primary refined	W	W	W	W	W
Exports	254,000	191,000	562,000	545,000	613,000
Imports for consumption	589,000	409,000	544,000	519,000	263,000
Dealers' price, average, commercial grade,[2] dollars per pound	51.43	24.57	33.08	32.29	23.07
World, refinery production	2,020,000 [r]	2,160,000 [r]	2,250,000 [r]	2,220,000 [r]	2,280,000
Tellurium, United States:					
Production, primary refined	W	W	W	W	W
Exports	51,000	3,550	15,100	50,000	8,130
Imports for consumption	42,200	31,100	43,700	102,000	84,000
Price at yearend, commercial grade,[3] dollars per kilogram	110.00	60.00	110.00	175.00	130.00

[r] Revised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Source: Platts Metals Week.

[3] Average yearend price published by Mining Journal for United Kingdom lump and powder, 99.95% tellurium. On September 14, 2010, the price was discontinued. For 2009, the price was the average September 14 price published by Mining Journal for United Kingdom lump and powder, 99.95% tellurium.

TABLE 2

U.S. EXPORTS OF SELENIUM[1]

	2008		2009	
Country	Quantity (kilograms, contained Se)	Value	Quantity (kilograms, contained Se)	Value
Argentina	--	--	5,540	$85,800
Australia	115,000	$1,790,000	93,200	1,440,000
Belgium	--	--	12,000	138,000
Canada	5,590	171,000	11,100	313,000
Chile	23,000	356,000	2,170	33,700
China	90,200	1,400,000	141,000	2,410,000
Colombia	3,480	61,000	3,970	67,500
Costa Rica	--	--	550	2,940
Dominican Republic	6,580	83,200	--	--
Germany	75,300	1,320,000	64,200	1,090,000
Hong Kong	49,500	1,050,000	151,000	2,650,000
India	12,300	191,000	--	--
Indonesia	--	--	3,470	51,900
Italy	479	7,430	245	3,800
Japan	2,500	38,800	2,530	39,300
Jordan	1,440	22,400	--	--
Korea, Republic of	58,600	886,000	51,100	832,000
Malaysia	3,120	48,300	170	2,630
Mexico	8,250	124,000	10,400	172,000
Netherlands	26,100	404,000	--	--
Panama	2,350	36,400	1,680	26,000
Peru	--	--	841	13,000
Philippines	4,600	90,500	--	--
Singapore	3,360	29,700	6,120	44,800
South Africa	4,500	69,700	141	9,280
Sweden	39,700	615,000	38,700	626,000
Taiwan	612	3,760	--	--
Thailand	31	2,830	--	--
United Kingdom	5,810	90,000	1,610	25,000
Venezuela	--	--	11,100	169,000
Vietnam	2,030	32,200	--	--
Total	545,000	8,920,000	613,000	10,200,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF SELENIUM[1]

Class and country	2008 Quantity (kilograms, contained Se)	2008 Value	2009 Quantity (kilograms, contained Se)	2009 Value
Selenium:				
Australia	2,000	$10,700	--	--
Belgium	234,000	9,960,000	39,100	$1,760,000
Canada	68,600	3,960,000	43,000	1,950,000
China	15,100	1,300,000	18,000	1,090,000
Germany	82,000	5,540,000	43,900	2,320,000
Hong Kong	--	--	1	3,400
India	5	9,500	--	--
Japan	22,600	1,270,000	19,600	846,000
Korea, Republic of	1,000	81,600	--	--
Mexico	23,800	1,450,000	42,000	1,680,000
Netherlands	4,670	140,000	1,280	54,000
Peru	-- r	-- r	1,800	64,000
Philippines	24,100 r	1,050,000 r	35,600	2,080,000
Russia	60 r	5,100 r	--	--
United Kingdom	30,100	1,620,000	15,700	897,000
Total	508,000	26,400,000	260,000	12,700,000
Selenium dioxide:[2]				
China	4,970	432,000	--	--
Germany	5,360	463,000	3,230	197,000
Japan	708	63,200	193	12,700
Total	11,000	958,000	3,420	210,000
Grand total	519,000	27,400,000	263,000	13,000,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Selenium content calculated as 71% of gross weight of material.

Source: U.S. Census Bureau.

TABLE 4

U.S. EXPORTS OF TELLURIUM[1]

	2008		2009	
Country	Quantity (kilograms, contained Te)	Value	Quantity (kilograms, contained Te)	Value
Belgium	722	$72,200	213	$32,000
Brazil	--	--	92	16,400
Canada	9,610	447,000	157	7,540
China	19,800	491,000	2,010	301,000
France	138	105,000	13	7,760
Germany	109	187,000	2,250	476,000
Hong Kong	4,610	374,000	1,880	161,000
India	7,000	175,000	95	13,100
Korea, Republic of	126	46,400	--	--
Malaysia	5,080	533,000	--	--
Mexico	38	5,110	--	--
Spain	900	410,000	--	--
Taiwan	28	4,260	556	81,000
United Kingdom	1,810	175,000	878	110,000
Total	50,000	3,030,000	8,130	1,210,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 5

U.S. IMPORTS FOR CONSUMPTION OF TELLURIUM[1]

	2008		2009	
Country	Quantity (kilograms, contained Te)	Value	Quantity (kilograms, contained Te)	Value
Belgium	6,570	$1,020,000	3,220	$227,000
Canada	10,100	2,430,000	18,300	4,030,000
China	70,100	11,500,000	39,400	3,310,000
Germany	1,230	139,000	12	7,880
Japan	73	54,700	3,020	485,000
Kazakhstan	--	--	200	36,000
Korea, Republic of	600	162,000	500	198,000
Mexico	--	--	2,790	377,000
Netherlands	1,040	252,000	52	3,500
Peru	4,200	660,000	--	--
Phillippines	2,000	132,000	10,200	1,890,000
Russia	5,550	1,380,000	5,780	691,000
Ukraine	247	11,400	--	--
United Kingdom	51	10,800	390	69,000
Total	102,000	17,700,000	84,000	11,300,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 6
SELENIUM: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Kilograms, contained selenium)

Country[3]	2005	2006	2007	2008[e]	2009[e]
Belgium[e]	200,000	200,000	200,000	200,000	200,000
Canada[4]	107,000	106,000	144,000	156,000 [5]	173,000 [5]
Chile[e]	84,000	74,000	70,000	78,000	70,000
Finland[e]	62,000 [5]	62,000	60,000	64,730 [r, 4]	65,000
Germany[e]	680,000 [r]	720,000 [r]	700,000 [r]	690,000 [r]	700,000
India[e, 6]	13,000	13,000	14,000	14,000	15,000
Japan	624,630	730,100	805,600	754,000	780,000 [5]
Peru	48,800	49,800	45,000	45,000	45,000
Philippines[e]	68,000	65,000	65,000	65,000	65,000
Russia[e]	100,000	110,000	120,000 [r]	130,000 [r]	140,000
Serbia[e]	8,315 [5, 7]	7,500	7,500	7,500	7,500
Sweden[e]	20,000	20,000	20,000	20,000	20,000
United States	W	W	W	W	W
Total	2,020,000 [r]	2,160,000 [r]	2,250,000 [r]	2,220,000 [r]	2,280,000

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data; not included in total.

[1] World totals and estimated data have been rounded to no more than three significant digits; may not add to totals shown.

[2] Insofar as possible, data relate to refinery output only; thus, countries that produced selenium contained in copper ores, copper concentrates, blister copper, and (or) refinery residues but did not recover refined selenium from these materials indigenously were excluded to avoid double counting. Table includes data available through June 7, 2010.

[3] In addition to the countries listed, Australia, China, Iran, Kazakhstan, Mexico, Poland, and Uzbekistan produced refined selenium, but output is not reported, and available information is inadequate for formulation of reliable estimates output levels. Australia is known to produce selenium in intermediate metallurgical products and has facilities to produce elemental selenium. In addition to having facilities for processing imported anode slimes for the recovery of selenium and precious metals, the United States has facilities for processing selenium scrap.

[4] Excludes selenium intermediates exported for refining.

[5] Reported figure.

[6] Data are for Indian fiscal year beginning April 1 of year stated.

[7] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

TABLE 7
TELLURIUM: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Kilograms, contained tellurium)

Country[3]	2005	2006	2007	2008[e]	2009[e]
Canada[4]	11,000	10,000	14,000	19,000	16,000
Japan	34,000	35,000	41,000	40,000	38,000
Peru	32,880	37,000 [r]	35,000 [r]	28,000 [r]	30,000 [p]
Russia[e]	34,000	34,000	34,000	34,000	34,000
United States	W	W	W	W	W

[e] Estimated. [p] Preliminary. [r] Revised. W Withheld to avoid disclosing company proprietary data.

[1] Estimated data are rounded to no more than three significant digits.

[2] Insofar as possible, data relate to refinery output only; thus, countries that produced tellurium contained in copper ores, copper concentrates, blister copper, and (or) refinery residues but did not recover refined tellurium are excluded to avoid double counting. Table is not totaled because of exclusion of data from major world producers.

[3] Australia, Belgium, Chile, China, Colombia, Germany, Mexico, the Philippines, Poland, and some countries of the Commonwealth of Independent States are known to produce refined tellurium, but output is not reported; available information is inadequate for formulation of reliable estimates of output levels.

[4] Excludes tellurium intermediates exported for refining.

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SILICA

By Thomas P. Dolley

Domestic survey data and tables were prepared by Gregory C. Winters, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

Four silica categories are covered in this report—industrial sand and gravel, quartz crystal (a form of crystalline silica), special silica stone products, and tripoli. Most of the stone covered in the special silica stone products section is novaculite. The section on tripoli includes tripoli and other fine-grained, porous silica materials, such as rottenstone, that have similar properties and end uses. Certain silica and silicate materials, such as diatomite and pumice, are covered in other chapters of the U.S. Geological Survey (USGS) Minerals Yearbook, volume I, Metals and Minerals. Trade data in this report are from the U.S. Census Bureau. All percentages were computed using unrounded data.

Industrial Sand and Gravel

Total industrial sand and gravel production decreased to 24.6 million metric tons (Mt) in 2009 from 30.4 Mt in 2008 (table 1). Industrial sand production decreased by 18%, and industrial gravel production, by 49%.

Industrial sand and gravel, often called "silica," "silica sand," and "quartz sand," includes sands and gravels with high silicon dioxide (SiO_2) content. Some examples of end uses for these sands and gravels are in abrasives, filtration, foundry, glassmaking, hydraulic fracturing (frac), and silicon metal applications. The specifications for each use vary, but silica resources for most uses are abundant. In almost all cases, silica mining uses open pit or dredging methods with standard mining equipment. Except for temporarily disturbing the immediate area while operations are active, sand and gravel mining usually has limited environmental impact.

The production decrease for silica sand in 2009 was largely owing to decreased demand as a result of the economic downturn that started in 2008 and continued into 2009. However, increased demand was noted for uses such as sand for water filtration with smaller increases for container glass, specialty glass, golf course sand, and recreational sand. Production of the remaining end uses for silica sand in 2009 experienced declines compared with that of the previous year. Demand for silica gravel declined for all end uses.

Legislation and Government Programs.—Effective January 24, 2008, the Occupational Safety and Health Administration (OSHA) announced a new National Emphasis Program to target worksites where employees are at risk for silicosis. Other elements included in the directive are an evaluation procedure for recording reductions of employee exposures to silica, as well as information on outreach programs, partnerships and alliances with employers to share resources, and training to reduce employee exposure (Occupational Safety and Health Administration, 2008, p. 10).

One of the most important issues affecting the industrial minerals industry in recent years has been the potential effect of crystalline silica on human health. Central to the ongoing and often heated debate have been the understanding of the regulations and the implementation of the measurements and actions taken to mitigate exposure to crystalline silica and appreciation of the impact of such exposure on the future of many industries (Industrial Minerals, 1998). OSHA created a permissible exposure limit that stipulated the maximum amount of crystalline silica to which workers may be safely exposed during an 8-hour work shift (29 CFR §§1926.55 and 1910.1000). OSHA also established guidelines and training for the proper handling of crystalline silica (Occupational Safety and Health Administration, 2002).

Production.—Domestic production data for industrial sand and gravel were developed by the USGS from a voluntary survey of U.S. producers. The USGS canvassed 68 producers with 124 operations known to produce industrial sand and gravel. Of the 124 surveyed operations, 119 (96%) were active, and 5 were idle. The USGS received responses from 78 operations, and their combined production represented 78% of the U.S. total. Production for the 46 nonrespondents was estimated, primarily on the basis of previously reported information supplemented with worker-hour reports from the Mine Safety and Health Administration and information from State agencies.

The Midwest (East North Central and West North Central divisions) led the Nation with 45% of the 24.6 Mt of industrial sand and gravel produced in the United States, followed by the South (South Atlantic, East South Central, and West South Central divisions) with 39%, and the West (Pacific and Mountain divisions) with 9%, and the Northeast (New England and Middle Atlantic) with 7% (table 2).

The leading producing States, in descending order, were Illinois, Wisconsin, Texas, Oklahoma, Michigan, California, North Carolina, and New Jersey (table 3). Their combined production represented 59% of the national total. States for which data have been withheld in table 3 are not included among the leading producers.

Of the total industrial sand and gravel produced, 82% was produced by 47 operations, each with production of 200,000 metric tons per year (t/yr) or more (table 4). The 10 leading producers of industrial sand and gravel were, in descending order, Unimin Corp.; U.S. Silica Co.; Badger Mining Corp.; Carmeuse Lime and Stone; Best Sand Corp. (a division of Fairmount Minerals Ltd.); Wisconsin Industrial Sand Co. (a division of Fairmount Minerals Ltd.); Manley Bros. of Indiana, Inc.; Sand Products Corp.; Preferred Rocks of Genoa, LLC; and Kinder Sand Co. Inc. Their combined production represented 78% of the U.S. total.

On November 29, 2008, a fire at Unimin Corp.'s Spruce Pine operation in North Carolina, caused significant damage to the

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SILICA

By Thomas P. Dolley

Domestic survey data and tables were prepared by Gregory C. Winters, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

Four silica categories are covered in this report—industrial sand and gravel, quartz crystal (a form of crystalline silica), special silica stone products, and tripoli. Most of the stone covered in the special silica stone products section is novaculite. The section on tripoli includes tripoli and other fine-grained, porous silica materials, such as rottenstone, that have similar properties and end uses. Certain silica and silicate materials, such as diatomite and pumice, are covered in other chapters of the U.S. Geological Survey (USGS) Minerals Yearbook, volume I, Metals and Minerals. Trade data in this report are from the U.S. Census Bureau. All percentages were computed using unrounded data.

Industrial Sand and Gravel

Total industrial sand and gravel production decreased to 24.6 million metric tons (Mt) in 2009 from 30.4 Mt in 2008 (table 1). Industrial sand production decreased by 18%, and industrial gravel production, by 49%.

Industrial sand and gravel, often called "silica," "silica sand," and "quartz sand," includes sands and gravels with high silicon dioxide (SiO_2) content. Some examples of end uses for these sands and gravels are in abrasives, filtration, foundry, glassmaking, hydraulic fracturing (frac), and silicon metal applications. The specifications for each use vary, but silica resources for most uses are abundant. In almost all cases, silica mining uses open pit or dredging methods with standard mining equipment. Except for temporarily disturbing the immediate area while operations are active, sand and gravel mining usually has limited environmental impact.

The production decrease for silica sand in 2009 was largely owing to decreased demand as a result of the economic downturn that started in 2008 and continued into 2009. However, increased demand was noted for uses such as sand for water filtration with smaller increases for container glass, specialty glass, golf course sand, and recreational sand. Production of the remaining end uses for silica sand in 2009 experienced declines compared with that of the previous year. Demand for silica gravel declined for all end uses.

Legislation and Government Programs.—Effective January 24, 2008, the Occupational Safety and Health Administration (OSHA) announced a new National Emphasis Program to target worksites where employees are at risk for silicosis. Other elements included in the directive are an evaluation procedure for recording reductions of employee exposures to silica, as well as information on outreach programs, partnerships and alliances with employers to share resources, and training to reduce employee exposure (Occupational Safety and Health Administration, 2008, p. 10).

One of the most important issues affecting the industrial minerals industry in recent years has been the potential effect of crystalline silica on human health. Central to the ongoing and often heated debate have been the understanding of the regulations and the implementation of the measurements and actions taken to mitigate exposure to crystalline silica and appreciation of the impact of such exposure on the future of many industries (Industrial Minerals, 1998). OSHA created a permissible exposure limit that stipulated the maximum amount of crystalline silica to which workers may be safely exposed during an 8-hour work shift (29 CFR §§1926.55 and 1910.1000). OSHA also established guidelines and training for the proper handling of crystalline silica (Occupational Safety and Health Administration, 2002).

Production.—Domestic production data for industrial sand and gravel were developed by the USGS from a voluntary survey of U.S. producers. The USGS canvassed 68 producers with 124 operations known to produce industrial sand and gravel. Of the 124 surveyed operations, 119 (96%) were active, and 5 were idle. The USGS received responses from 78 operations, and their combined production represented 78% of the U.S. total. Production for the 46 nonrespondents was estimated, primarily on the basis of previously reported information supplemented with worker-hour reports from the Mine Safety and Health Administration and information from State agencies.

The Midwest (East North Central and West North Central divisions) led the Nation with 45% of the 24.6 Mt of industrial sand and gravel produced in the United States, followed by the South (South Atlantic, East South Central, and West South Central divisions) with 39%, and the West (Pacific and Mountain divisions) with 9%, and the Northeast (New England and Middle Atlantic) with 7% (table 2).

The leading producing States, in descending order, were Illinois, Wisconsin, Texas, Oklahoma, Michigan, California, North Carolina, and New Jersey (table 3). Their combined production represented 59% of the national total. States for which data have been withheld in table 3 are not included among the leading producers.

Of the total industrial sand and gravel produced, 82% was produced by 47 operations, each with production of 200,000 metric tons per year (t/yr) or more (table 4). The 10 leading producers of industrial sand and gravel were, in descending order, Unimin Corp.; U.S. Silica Co.; Badger Mining Corp.; Carmeuse Lime and Stone; Best Sand Corp. (a division of Fairmount Minerals Ltd.); Wisconsin Industrial Sand Co. (a division of Fairmount Minerals Ltd.); Manley Bros. of Indiana, Inc.; Sand Products Corp.; Preferred Rocks of Genoa, LLC; and Kinder Sand Co. Inc. Their combined production represented 78% of the U.S. total.

On November 29, 2008, a fire at Unimin Corp.'s Spruce Pine operation in North Carolina, caused significant damage to the plant. Most of the damage was in the quartz processing facility with some damage to the feldspar facility. The fire was expected to significantly impact U.S. production of quartz, feldspar, and mica. Unimin Corp. produces an estimated 130,000 t/yr of quartz and feldspar at the facility (Industrial Minerals, 2008).

Consumption.—Industrial sand and gravel production reported by producers to the USGS was material used by the producing companies or sold to their customers. Stockpiled material is not reported until consumed or sold. Of the 24.6 Mt of industrial sand and gravel sold or used, 32% was consumed as glassmaking sand, and 27% as frac sand and sand for well packing and cementing (table 6). Foundry sand consumed 13% of industrial sand and gravel consumption. Other important uses were whole grain fillers and building products (7%) and other whole grain silica (5%).

Minable deposits of industrial sand and gravel occur throughout the United States, and successful mining companies are located near markets that have traditionally been in the Eastern United States. In some cases, consuming industries are specifically located near a silica resource. The automotive industry was originally located in the Midwest near clay, coal, iron, and silica resources. Therefore, foundry sands have been widely produced in Illinois, Indiana, Michigan, Ohio, and other Midwestern States. In 2009, at least 79% of foundry sand was produced in the Midwest.

Producers of industrial sand and gravel were asked to provide statistics on the destination of silica produced at their operations. The producers were asked to list only the quantity of shipments (no value data were collected in this section of the questionnaire) and to which State or other location the material was shipped for consumption. The States that received the most industrial sand and gravel were Texas (12.4%), Illinois (5.3%), Wisconsin (4.6%), Colorado (4.3%), Georgia (3.3%), and Indiana (3.2%). Producers reported sending at least 293,000 t of silica to Mexico and 298,000 t to Canada (table 7). Because some producers did not provide this information, their data were estimated or assigned to the "Destination unknown" category. In 2009, 16% of industrial sand and gravel shipped by producers was assigned to that category.

The share of silica sold for all types of glassmaking remained unchanged compared with that of 2008. In 2009, sales to container glass manufacturers declined compared with those in 2008. On average, in the container glassmaking industry, silica accounts for 60% of raw materials used (Industrial Minerals, 2004). The amount of unground silica sand consumed for fiberglass production decreased by 37% compared with that of 2008.

In 2009, sales of sand for flat glass production decreased by 28% compared with those in 2008. Consumption of sand for flat glass declined in all regions of the country in 2009.

Whole grain silica is used in filler-type and building applications. In 2009, consumption of whole-grain fillers for building products was 1.7 Mt, down 23% compared with that in 2008.

In table 6, industrial sand and gravel that would find its way into specialty silicas is most likely reported by the producers in the categories "Sand, abrasives, chemicals, ground and unground," "Gravel, silicon, ferrosilicon," and possibly "Glassmaking, specialty." In 2009, silica sales for chemical production were 669,000 t, a decrease of about 19% compared with those in 2008. According to the USGS survey, reported sales of silica gravel for silicon and ferrosilicon production, filtration, and other uses, decreased by 49% in 2009 compared with those in 2008. The main uses for silicon metal are in the manufacture of silanes and semiconductor-grade silicon and in the production of aluminum alloys.

Transportation.—Of all industrial sand and gravel produced, 52% was transported by truck from the plant to the site of first sale or use, unchanged from that of 2008; 35% was transported by rail, up from that of 2008; and 13% by unspecified modes of transport.

Prices.—Compared with the average value of 2008, the average value, free on board plant, of U.S. industrial sand and gravel increased slightly to $31.90 per metric ton in 2009 (table 6). The average unit values for industrial sand and industrial gravel were $31.77 per ton and $37.18 per ton, respectively. The average price for sand ranged from $10.41 per ton for metallurgical flux for metal smelting to $131.17 per ton for ground sand for foundry molding and core. For gravel, prices ranged from $23.65 per ton for silicon and ferrosilicon to $50.46 per ton for other uses. Producer prices reported to the USGS for silica commonly ranged from several dollars per ton to hundreds of dollars per ton. Prices occasionally exceeded the $1,000-per-ton level. Nationally, ground sand for foundry molding and core had the highest value ($131.17 per ton), followed by silica for swimming pool filters ($91.45 per ton), silica for sawing and sanding ($79.00 per ton), ground sand used as fillers for paint, putty, and rubber ($67.31 per ton), sand for well packing and cementing ($62.48 per ton), ground sand for fiberglass ($50.82 per ton), and sand for hydraulic fracturing ($48.87 per ton).

By geographic region, the average value of industrial sand and gravel was highest in the Midwest ($34.19 per ton), followed by the South ($30.94 per ton), the Northeast ($29.34 per ton), and the West ($26.50 per ton) (table 6). Prices can vary greatly for similar grades of silica at different locations in the United States, along with tighter supplies and higher production costs in certain regions of the country. For example, the average value of container glass sand varied from $25.89 per ton in the West to $17.51 per ton in the Midwest.

Foreign Trade.—Exports of industrial sand and gravel in 2009 decreased by about 31% compared with the amount exported in 2008 and the associated value decreased by 33% (table 8). The decrease in exports can be attributed mainly to decreased demand from markets in Africa and the Middle East, Asia, Europe, and Oceania. Canada was the leading recipient of U.S. exports. The distribution of exports was as follows: 53% to Canada, 20% to Mexico, 18% to Japan, and the remainder to Africa and the Middle East, Europe, Oceania, and South America. The average unit value of exports decreased to $81 per ton in 2009 from $84 per ton in 2008. In 2009, export unit values varied widely by region; exports of silica to Oceania averaged $531 per ton, and exports to the rest of the world averaged $81 per ton.

Imports for consumption of industrial sand and gravel declined to 95,000 t, which was a decrease of 73% compared with those of 2008 (table 9). Canada supplied 93% of the silica imports, which averaged $47 per ton; this price included insurance and freight costs to the U.S. port of entry. The total value of imports was $8 million, with an average unit value of $85 per ton. Higher priced imports came from Australia, Chile, China, Germany, and Japan.

World Review.—Based on information provided mainly by foreign governments, world production of industrial sand and gravel was estimated to be 106 Mt (table 10). The United States was the leading producer followed, in descending order, by Italy, Germany, the United Kingdom, Australia, France, Spain, and Poland. Most countries had some production and consumption of industrial sand and gravel, which are essential to the glass and foundry industries. Because of the great variation in reporting standards, however, obtaining reliable information was difficult. In addition to the countries listed, many other countries were thought to have had some type of silica production and consumption.

Outlook.—U.S. consumption of industrial sand and gravel in 2010 was expected to be 25 to 27 Mt. All forecasts are based on previous performances within various end uses, contingency factors considered relevant to the future of the commodity, and forecasts made by analysts and producers in the various markets.

Sales of glass sand can be expected to vary from market to market. Growth has been noted in some segments, such as sand for container glass, golf course, municipal water filtration, recreation, specialty, and whole grain silica. Total demand for all glass sand end uses was expected to remain relatively static through 2010. Industrial sand and gravel sales may also be constrained by diminished demand owing to the continued economic downturn and by the rising energy costs for production and transportation of products.

The demand for foundry sand is dependent mainly on automobile and light truck production. Production and sales of automobiles and light trucks declined in 2009 and the trend continued into 2010. Another important factor for the future consumption of virgin foundry sand is the recycling of used foundry sand. The level of recycling is thought to be increasing. Other materials or minerals compete with silica as foundry sand, but these other "sands" usually suffer from a severe price disadvantage. Based on these factors, production of silica foundry sand in 2010 was expected to be 3 Mt.

Frac sand sales declined in 2009 compared with those in 2008. On average, crude oil prices decreased in 2009 but started to increase in 2010. Based on this trend, coupled with natural gas exploration in the Eastern United States, demand for frac sand was expected to remain static or increase during 2010 to 7 Mt.

The United States is the leading producer and a major consumer of silica sand and is self-sufficient in this mined commodity. Most silica sand is produced at deposits in the Midwest and near major markets in the Eastern United States. A significant amount of silica sand also is produced in the West and Southwest, mostly in California and Texas, respectively. Domestic production is expected to continue to meet 97% to 98% of demand well beyond 2010. Imports, mostly from Canada and Mexico, and higher valued material from China are expected to remain minor.

Because the unit price of silica sand is relatively low, except for a few end uses that require a high degree of processing, the location of a silica sand deposit in relation to market location is an important factor that may work for or against a sand producer. Consequently, a significant number of relatively small operations supply local markets with a limited number of products.

Several factors could affect supply and demand relationships for silica sand. Further increases in the development of substitute materials for glass and cast metals could potentially reduce demand for foundry and glass sand. These substitutes, which are mainly ceramics and polymers, would likely increase the demand for ground silica, which is used as a filler in plastics; glass fibers, which are used in reinforced plastics; and silica (chemical, ground, or whole-grain), which is used as raw materials for ceramics. Increased efforts to reduce waste and to increase recycling also could likely lower the demand for mined glass sand. Recycling of glass cullet has been increasing in most industrialized nations, and recycling has accounted for anywhere from 25% to 70% of the raw material needed for the glass container industry in many countries. It has been estimated that for every 10% of recycled glass cullet used in the melting process for glass container manufacture, energy use will fall by approximately 2.5%. During the past 20 years, glass container weight has been reduced by 25% to 40% in many nations, including the United States, decreasing the amount of industrial sand required for each container (Industrial Minerals, 2004). Although other developments could likely cause the demand for silica sand to decrease, the total value of production would likely increase because of the increased unit value of the more specialized sands.

Health concerns about the use of silica as an abrasive and stricter legislative and regulatory measures concerning crystalline silica exposure could potentially reduce the demand in many silica markets. The use of silica sand in the abrasive blast industry was being evaluated as a health hazard, and marketers of competing materials, which include garnet, olivine, and slags, encouraged the use of their "safer" abrasive media. In hydraulic fracturing, other materials (such as bauxite-based proppants, ceramic proppants, and resin-coated sand) compete with silica sand, although they are more expensive and not used as extensively as silica sand. Bauxite-based and ceramic proppants exhibit improved performance in deeper, higher pressure formations than silica sand (Industrial Minerals, 2009).

Quartz Crystal

Electronic-grade quartz crystal, also known as cultured quartz crystal, is single-crystal silica with properties that make it uniquely suited for accurate filters, frequency controls, and timers used in electronic circuits. These devices are used for a variety of electronic applications in aerospace hardware, commercial and military navigational instruments, communications equipment, computers, and consumer goods (for example, clocks, games, television receivers, and toys). Such uses generate practically all the demand for electronic-grade quartz crystal. A smaller amount of optical-grade quartz crystal is used for lenses and windows in specialized devices, which include some lasers.

Natural quartz crystal was used in most electronic and optical applications until 1971, when it was surpassed by cultured quartz crystal. Cultured quartz is not a mined mineral commodity. Rather, it is synthetically produced from natural feedstock quartz, termed lascas, which is mined. Mining of lascas in the United States ceased in 1997 owing to competition from less expensive imported lascas predominantly from mines in Brazil and Madagascar.

Additionally, it has been estimated that in any given year, approximately 10 billion quartz crystals and oscillators are manufactured and installed worldwide in all types of electronic devices, from automobiles to cellular telephones.

The use of natural quartz crystal for carvings and other gemstone applications has continued; more information can be found in the "Gemstones" chapter of the USGS Minerals Yearbook, volume I, Metals and Minerals.

Legislation and Government Programs.—The strategic value of quartz crystal was demonstrated during World War II when it gained widespread use as an essential component of military communication systems. After the war, natural electronic-grade quartz crystal was officially designated as a strategic and critical material for stockpiling by the Federal Government. Cultured quartz crystal, which eventually supplanted natural crystal in nearly all applications, was not commercially available when acquisition of natural quartz crystal for a national stockpile began.

As of December 31, 2009, the National Defense Stockpile (NDS) contained 7,134 kilograms (kg) of natural quartz crystal. The stockpile has 11 weight classes for natural quartz crystal that range from 0.2 kg to more than 10 kg. The stockpiled crystals, however, are primarily in the larger weight classes. The larger pieces are suitable as seed crystals, which are very thin crystals cut to exact dimensions, to produce cultured quartz crystal. In addition, many of the stockpiled crystals could be of interest to the specimen and gemstone industry. Little, if any, of the stockpiled material is likely to be used in the same applications as cultured quartz crystal.

No natural quartz crystal was sold from the NDS in 2009, and the Federal Government did not intend to dispose of or sell any of the remaining material. Previously, only individual crystals in the NDS inventory that weighed 10 kg or more and could be used as seed material were sold. Brazil traditionally has been the source of such large natural crystals, but changes in mining operations have reduced output.

Quartz crystal is also affected by the regulation of crystalline silica as discussed in the "Legislation and Government Programs" portion of the "Industrial Sand and Gravel" section of this chapter.

Production.—The USGS collects production data for quartz crystal through a survey of the domestic industry. In 2009, no domestic companies reported the production of cultured quartz crystal. During the past several years, cultured quartz crystal was produced predominantly overseas, primarily in Asia.

Consumption.—In 2009, the USGS collected domestic consumption data for quartz crystal through a survey of 23 U.S. operations that fabricate quartz crystal devices in 9 States. Of the 23 operations, 7 responded to the survey. Consumption for nonrespondents was estimated based on reports from previous years.

Prices.—The price of as-grown quartz was estimated to be $100 per kilogram in 2009. Lumbered quartz, which is as-grown cultured quartz that has been processed by sawing and grinding, ranged in price from $144 per kilogram to more than $900 per kilogram in 2009, depending on the application.

Foreign Trade.—The U.S. Census Bureau, which is the major Government source of U.S. trade data, does not provide specific import or export statistics on lascas. The U.S. Census Bureau collects export and import statistics on electronic and optical-grade quartz crystal; however, the quartz crystal export and import quantities and values reported in previous years included zirconia, which was inadvertently reported as quartz crystal, not including mounted piezoelectric crystals.

World Review.—Cultured quartz crystal production was concentrated in China, Japan, and Russia; several companies produced crystal in each country. Other producing countries were Belgium, Brazil, Bulgaria, France, Germany, South Africa, and the United Kingdom. Details concerning quartz operations in China, the Eastern European countries, and most nations of the Commonwealth of Independent States were unavailable. Operations in Russia, however, have significant capacity to produce synthetic quartz.

Outlook.—Growth of the consumer electronics market (for example, automobiles, cellular telephones, electronic games, and personal computers), particularly in the United States, will likely continue to provide consumer outlets for domestic production of quartz crystal devices. The increasing global electronics market may require additional production capacity worldwide. Quartz technology could face competition in the near future with the advent of more cost effective microelectromechanical systems (MEMS). MEMS technology was first developed in 1965 and consisted of silicon on insulated wafers. MEMS technology is physically compatible with existing quartz oscillator products and has better long-term stability performance characteristics for use in automotive, consumer, and computational products, and wireless applications (Partridge, 2006).

Special Silica Stone Products

Silica stone (another type of crystalline silica) products are materials for abrasive tools, such as deburring media, grinding pebbles, grindstones, hones, oilstones, stone files, tube-mill liners, and whetstones. These products are manufactured from novaculite, quartzite, and other microcrystalline quartz rock. This chapter, however, excludes products that are fabricated from such materials by artificial bonding of the abrasive grains (information on other manufactured and natural abrasives may be found in other USGS Minerals Yearbook, volume I, Metals and Minerals chapters).

Special silica stone is also affected by the regulation of crystalline silica as discussed in the "Legislation and Government Programs" part of the "Industrial Sand and Gravel" section of this chapter.

Production.—None of the three domestic firms known to produce special silica stone responded to a USGS production survey in 2009. To protect the proprietary data of all producers, production and value data for special silica stone in 2009 were withheld (table 1). In recent years, Arkansas accounted for most of the value and quantity of production that was reported. Plants in Arkansas manufactured files, deburring-tumbling media, oilstones, and whetstones.

The industry produced and marketed four main grades of Arkansas whetstone in recent years. The grades range from the high-quality black hard Arkansas stone down to Washita stone. In general, the black hard Arkansas stone has a porosity of 0.07% and a waxy luster, and Washita stone has a porosity of 16% and resembles unglazed porcelain.

Consumption.—The domestic consumption of special silica stone products comprises a combination of craft, household, industrial, and leisure uses. The leading household use is for sharpening knives and other cutlery, lawn and garden tools, scissors, and shears. Major industrial uses include deburring metal and plastic castings, polishing metal surfaces, and sharpening and honing cutting surfaces. The major recreational use is in sharpening arrowheads, fishhooks, spear points, and sports knives. The leading craft application is sharpening tools for engraving, jewelry making, and woodcarving. Silica stone files also are used in the manufacture, modification, and repair of firearms.

Prices.—In 2009, the average value of crude material suitable for cutting into finished products was estimated to be $3,700 per ton.

Foreign Trade.—In 2009, silica stone product exports had a value of $7.6 million, down by 13% from that in 2008. These exports were categorized as "hand sharpening or polishing stones" by the U.S. Census Bureau. This category accounted for most of or all the silica stone products exported in 2009.

In 2009, the value of imported silica stone products was $8.3 million, down by 11% from that in 2008. These imports were hand sharpening or polishing stones, which accounted for most of or all the imported silica stone products in 2009. A portion of the finished products that were imported may have been made from crude novaculite produced in the United States and exported for processing.

Outlook.—Consumption patterns for special silica stone were not expected to change significantly during the next several years. Most of the existing markets are well defined, and the probability of new uses being created is low.

Tripoli

Tripoli, broadly defined, includes extremely fine grained crystalline silica in various stages of aggregation. Grain sizes usually range from 1 to 10 micrometers (μm), but particles as small as 0.1 to 0.2 μm are common. Commercial tripoli contains 98% to 99% silica and minor amounts of alumina (as clay) and iron oxide. Tripoli may be white or some shade of brown, red, or yellow depending on the percentage of iron oxide.

Tripoli also is affected by the regulation of crystalline silica as discussed in the "Legislation and Government Programs" part of the "Industrial Sand and Gravel" section of this chapter.

Production.—In 2009, five U.S. firms were known to produce and process tripoli. American Tripoli, Inc. produced crude material in Ottawa County, OK, and finished material in Newton County, MO. Keystone Filler and Manufacturing Co. in Northumberland County, PA, processed rottenstone, which is decomposed fine-grained siliceous shale, purchased from local suppliers. Malvern Minerals Co. in Garland County, AR, produced crude and finished material from novaculite. Harbison-Walker Refractories Co. in Hot Springs County, AR, produced crude and finished tripoli that is consumed in the production of refractory bricks and shapes. Unimin Specialty Minerals Inc. in Alexander County, IL, produced crude and finished material. Of the five U.S. firms, two responded to the USGS survey. Production for nonrespondents was estimated based on reports from previous years.

Consumption.—The 2009 USGS annual survey of producers indicated that sales of processed tripoli decreased by 40% in quantity to 79,700 t with a value of $16.4 million (table 1).

Tripoli has unique applications as an abrasive because of its hardness and its grain structure, which lacks distinct edges and corners. It is a mild abrasive, which makes it suitable for use in toothpaste and tooth-polishing compounds, industrial soaps, and metal- and jewelry-polishing compounds. The automobile industry uses it in buffing and polishing compounds for lacquer finishing.

The end-use pattern for tripoli has changed significantly in the past 40 years. In 1970, nearly 70% of the processed tripoli was used as an abrasive. In 2009, 6% of tripoli output was used as an abrasive. Tripoli also was used in brake friction products and as a filler and extender in enamel, caulking compounds, linings, paint, plastic, refractories, rubber, and other products.

In 2009, the primary use of tripoli (91%) was as a filler and extender in paints. The remaining 3% was in brake friction products and refractories.

Price.—The average reported unit value of all tripoli sold or used in the United States was $206 per ton in 2009. The average reported unit value of abrasive-grade tripoli sold or used in the United States during 2009 was $217 per ton, and the average reported unit value of filler-grade tripoli sold or used domestically was $211 per ton.

Outlook.—Consumption patterns for tripoli were not expected to change significantly during the next several years. Most of the existing markets are well defined, and the probability of new uses being created is low.

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TABLE 1

SALIENT U.S. SILICA STATISTICS[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

	2005	2006	2007	2008	2009
Industrial sand and gravel:[2]					
Sold or used:					
Quantity:					
Sand	29,700	28,200	29,000	29,300	24,000
Gravel	955	725	1,010	1,110	565
Total	30,600	28,900	30,100	30,400	24,600
Value:					
Sand	733,000	745,000	810,000	909,000	762,000
Gravel	19,500	13,400	21,300	28,000	21,000
Total	752,000	759,000	832,000	940,000	783,000
Exports:					
Quantity	2,910	3,830	3,020	3,100	2,150
Value	154,000	183,000	242,000	260,000	175,000
Imports for consumption:					
Quantity	711	855	511	355	95
Value	18,200	21,000	24,000	23,500	8,080
Processed tripoli:[3]					
Quantity metric tons	91,100	76,000	96,400	132,000	79,700
Value	18,700	17,500	17,400	17,100	16,400
Special silica stone:					
Crude production:					
Quantity metric tons	193	227	231	W	W
Value	191	992	1,020	W	W
Sold or used:					
Quantity metric tons	576	328	508	W	W
Value	2,290	1,460	823	W	W

W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes Puerto Rico.

[3] Includes amorphous silica and Pennsylvania rottenstone.

TABLE 2

INDUSTRIAL SAND AND GRAVEL SOLD OR USED IN THE UNITED STATES, BY GEOGRAPHIC DIVISION[1]

	2008				2009			
Geographic region	Quantity (thousand metric tons)	Percentage of total	Value (thousands)	Percentage of total	Quantity (thousand metric tons)	Percentage of total	Value (thousands)	Percentage of total
Northeast:								
New England	147	(2)	$5,160	(2) r	130	(2)	$4,510	(2)
Middle Atlantic	1,710	6	48,600	5	1,670	7	48,200	6
Midwest:								
East North Central	9,890	33	291,000	31	8,470	34	266,000	34
West North Central	2,600	9	120,000	13	2,630	11	113,000	14
South:								
South Atlantic	4,250	14	102,000	11	3,480	14	89,900	11
East South Central	1,660	5	48,200	5	1,210	5	39,200	5
West South Central	7,230	24	243,000	26	4,780	19	164,000	21
West:								
Mountain	1,030	3	30,200	3	531	2	12,600	2
Pacific	1,920	6	52,700	6	1,670	7	45,600	6
Total	30,400	100	940,000	100	24,600	100	783,000	100

rRevised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

TABLE 3
INDUSTRIAL SAND AND GRAVEL SOLD OR USED IN THE UNITED STATES, BY STATE[1]

(Thousand metric tons and thousand dollars)

	2008		2009	
State	Quantity	Value	Quantity	Value
Alabama	619	14,600	370	11,200
Arizona	W	W	W	W
Arkansas	W	W	W	W
California	1,500	42,300	1,300	35,800
Colorado	W	W	W	W
Florida	573	7,480	431	8,270
Georgia	841	20,700	775	19,300
Idaho	W	W	W	W
Illinois	3,980	108,000	3,440	104,000
Indiana	W	W	W	W
Iowa	W	W	W	W
Kansas	W	W	W	W
Louisiana	748	23,100	682	25,900
Maryland	W	W	--	--
Michigan	1,500	26,800	1,330	27,700
Minnesota	W	W	W	W
Mississippi	W	W	W	W
Missouri	648	21,400	763	28,900
Nebraska	--	--	W	W
Nevada	W	W	W	W
New Jersey	1,010	31,800	906	30,200
New Mexico	W	W	--	--
New York	W	W	W	W
North Carolina	1,510	29,400	1,300	28,000
North Dakota	W	W	W	W
Ohio	1,010	34,300	849	26,300
Oklahoma	2,040	63,700	1,410	40,300
Pennsylvania	677	16,300	618	15,600
Rhode Island	W	W	W	W
South Carolina	679	21,100	441	14,000
Tennessee	983	32,800	783	27,100
Texas	3,590	139,000	2,130	84,400
Virginia	W	W	W	W
Washington	W	W	W	W
West Virginia	338	17,200	241	14,700
Wisconsin	3,290	120,000	2,730	105,000
Other	4,910	171,000	4,070	137,000
Total	30,400	940,000	24,600	783,000

W Withheld to avoid disclosing company proprietary data; included in "Other." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 4
INDUSTRIAL SAND AND GRAVEL PRODUCTION IN THE UNITED STATES IN 2009, BY SIZE OF OPERATION[1]

Size range	Number of operations	Percentage of total	Quantity (thousand metric tons)	Percentage of total
Less than 25,000	19	16	228	(2)
25,000 to 49,999	14	11	461	1
50,000 to 99,999	19	16	1,150	4
100,000 to 199,999	20	16	2,600	10
200,000 to 299,999	14	11	3,050	12
300,000 to 399,999	8	6	2,350	9
400,000 to 499,999	6	5	2,400	9
500,000 to 599,999	4	3	W	W
600,000 to 699,999	9	7	5,240	21
700,000 and more	6	5	W	W
Total	119	100	24,600	100

W Withheld to avoid disclosing company proprietary data; included in "Total."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

TABLE 5
NUMBER OF INDUSTRIAL SAND AND GRAVEL OPERATIONS AND PROCESSING PLANTS IN THE UNITED STATES IN 2009, BY GEOGRAPHIC DIVISION

Geographic region	Mining operations on land: Stationary	Mining operations on land: Portable	Mining operations on land: Stationary and portable	Dredging operations	Total active operations
Northeast:					
New England	1	--	--	--	1
Middle Atlantic	4	--	--	4	8
Midwest:					
East North Central	23	--	3	3	29
West North Central	9	--	--	2	11
South:					
South Atlantic	17	1	--	4	22
East South Central	8	--	--	2	10
West South Central	16	--	--	7	22
West:					
Mountain	4	--	1	--	5
Pacific	11	--	--	--	11
Total	93	1	4	22	119

-- Zero.

TABLE 6
INDUSTRIAL SAND AND GRAVEL SOLD OR USED BY U.S. PRODUCERS IN 2009, BY MAJOR END USE[1]

	Northeast			Midwest			South		
Major use	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)
Sand:									
Glassmaking:									
Containers	608	14,700	$24.11	1,180	$20,600	$17.51	1,750	$35,400	$20.18
Flat, plate and window	107	2,340	21.91	W	W	16.92	985	21,700	22.01
Specialty	93	3,160	34.00	284	6,110	21.52	175	6,120	34.95
Fiberglass, unground	W	W	21.58	146	2,390	16.34	286	5,890	20.58
Fiberglass, ground	--	--	--	28	1,870	66.71	276	13,600	49.21
Foundry:									
Molding and core, unground	82	2,230	27.20	2,490	45,600	18.29	451	10,100	22.29
Molding and core, ground	--	--	--	5	714	142.80	(3)	73	112.00
Refractory	(3)	5	40.00	16	745	46.56	28	889	31.75
Metallurgical, flux for metal smelting	--	--	--	--	--	--	W	W	23.67
Abrasives:									
Blasting	45	1,060	23.64	34	1,980	58.35	281	13,100	46.73
Sawing and sanding	W	W	103.00	--	--	--	W	W	55.00
Chemicals, ground and unground	2	84	42.00	231	4,660	20.17	438	16,300	37.25
Fillers, ground, rubber, paints, putty, etc.	7	405	57.86	219	9,920	45.31	W	W	226.68
Whole-grain fillers/building products	292	11,300	38.86	365	14,400	39.45	784	25,900	33.02
Ceramic, ground, pottery, brick, tile, etc.	--	--	--	30	2,250	75.00	57	4,600	80.70
Filtration:									
Water, municipal, county, local	42	2,850	67.74	147	2,590	17.63	48	2,880	59.94
Swimming pool, other	12	1,000	83.33	17	1,410	83.00	39	3,900	99.97
Petroleum industry:									
Hydraulic fracturing	W	W	35.94	4,680	235,000	50.19	1,770	81,300	46.01
Well packing and cementing	--	--	--	28	2,200	78.71	70	3,020	43.14
Recreational:									
Golf course, greens and traps	151	3,790	25.11	217	5,210	23.99	378	6,150	16.26
Baseball, volleyball, play sand, beaches	24	1,010	41.88	55	1,730	31.38	41	1,300	31.73
Traction, engine	14	539	38.50	21	394	18.76	33	919	27.85
Roofing granules and fillers	W	W	35.46	113	3,790	33.57	236	4,960	21.00
Other, ground silica	W	W	50.00	7	185	26.43	97	8,220	18.02
Other, whole grain	290	6,370	15.76	695	12,800	22.86	851	11,900	13.92
Total or average	1,770	51,000	28.78	11,000	376,000	34.19	9,070	278,000	30.65
Gravel:									
Silicon, ferrosilicon	--	--	--	W	W	17.00	211	5,010	23.76
Filtration	W	W	71.20	W	W	20.07	W	W	53.32
Other uses, specified	7	767	109.57	64	2,600	40.63	151	8,140	53.91
Total or average	21	1,650	78.57	94	3,210	34.17	395	14,800	37.53
Grand total or average	1,800	52,700	29.34	11,100	380,000	34.19	9,470	293,000	30.94

See footnotes at end of table.

TABLE 6—Continued
INDUSTRIAL SAND AND GRAVEL SOLD OR USED BY U.S. PRODUCERS IN 2009, BY MAJOR END USE[1]

Major use	West			U.S. total		
	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)
Sand:						
Glassmaking:						
Containers	791	$20,500	$25.89	4,330	$91,100	$21.05
Flat, plate and window	468	12,100	25.79	2,080	44,900	21.59
Specialty	W	W	54.00	556	15,600	28.07
Fiberglass, unground	W	W	24.59	509	10,200	19.95
Fiberglass, ground	W	W	44.25	311	15,800	50.82
Foundry:						
Molding and core, unground	101	2,150	21.30	3,130	60,100	19.20
Molding and core, ground	--	--	--	6	787	131.17
Refractory	--	--	--	44	1,640	37.25
Metallurgical, flux for metal smelting	W	W	7.57	W	W	10.41
Abrasives:						
Blasting	69	1,030	14.90	430	17,200	40.02
Sawing and sanding	--	--	--	W	W	79.00
Chemicals, ground and unground	11	328	29.82	669	21,100	31.48
Fillers, ground, rubber, paints, putty, etc.	W	W	49.33	260	17,500	67.31
Whole grain fillers/building products	278	9,120	32.82	1,720	60,800	35.35
Ceramic, ground, pottery, brick, tile, etc.	W	W	42.50	88	6,940	78.81
Filtration:						
Water, municipal, county, local	15	747	49.80	251	9,060	36.10
Swimming pool, other	--	--	--	69	6,310	91.45
Petroleum industry:						
Hydraulic fracturing	W	W	34.73	6,530	319,000	48.87
Well packing and cementing	14	1,770	126.71	112	7,000	62.48
Recreational:						
Golf course, greens and traps	188	4,070	21.65	935	19,200	20.55
Baseball, volleyball, play sand, beaches	W	W	27.57	127	4,230	33.28
Traction, engine	4	173	43.25	73	2,020	27.73
Roofing granules and fillers	W	W	40.50	382	9,900	25.92
Other, ground silica	23	973	38.60	87	1,960	22.53
Other, whole grain	181	3,980	11.45	1,300	19,900	15.33
Total or average	2,140	56,900	26.57	24,000	762,000	31.77
Gravel:						
Silicon, ferrosilicon	W	W	23.47	258	6,100	23.65
Filtration	--	--	--	W	W	42.10
Other uses, specified	W	W	29.67	W	W	50.46
Total or average	55	1,320	24.04	565	21,000	37.18
Grand total or average	2,200	58,200	26.50	24,600	783,000	31.90

W Withheld to avoid disclosing company proprietary data; for sand, included in "Other, ground silica" or "Other, whole grain"; for gravel, included in "Total or average." -- Zero.

[1] Data are rounded to no more than three significant digits except for unit values; may not add to totals shown.

[2] Calculated using unrounded data.

[3] Less than ½ unit.

TABLE 7
INDUSTRIAL SAND AND GRAVEL SOLD OR USED, BY DESTINATION[1]

(Thousand metric tons)

Destination	2008	2009
States:		
Alabama	405 r	361
Alaska	W	W
Arizona	W	W
Arkansas	536	748
California	W	W
Colorado	1,470	1,050
Connecticut	72	67
Delaware	23	30
District of Columbia	W	W
Florida	W	657
Georgia	829	788
Hawaii	W	W
Idaho	W	W
Illinois	1,350	1,280
Indiana	917	792
Iowa	W	W
Kansas	289	194
Kentucky	W	W
Louisiana	472	480
Maine	W	W
Maryland	W	W
Massachusetts	106	W
Michigan	427	341
Minnesota	W	W
Mississippi	79	52
Missouri	W	W
Montana	9	9
Nebraska	W	W
Nevada	W	W
New Hampshire	W	W
States—Continued:		
New Jersey	W	W
New Mexico	130	90
New York	W	W
North Carolina	W	W
North Dakota	185	167
Ohio	696	588
Oklahoma	987	516
Oregon	W	65
Pennsylvania	W	W
Rhode Island	25	22
South Carolina	W	W
South Dakota	W	W
Tennessee	599	471
Texas	4,600	3,020
Utah	18	W
Vermont	W	W
Virginia	214	172
Washington	W	W
West Virginia	W	74
Wisconsin	1,390	1,130
Wyoming	312	371
Countries:		
Canada	467	298
Mexico	357	293
Other	12	7
Other:		
Puerto Rico	W	W
U.S. possessions and territories	W	W
Destination unknown	5,420	3,940
Total	30,400	24,300

r Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 8

U.S. EXPORTS OF INDUSTRIAL SAND AND GRAVEL, BY REGION AND COUNTRY[1]

(Thousand metric tons and thousand dollars)

Destination	2008		2009	
	Quantity	Value[2]	Quantity	Value[2]
Africa and the Middle East:				
Egypt	(3)	147	--	--
Israel	2	511	(3)	301
Other	9	948	6	938
Total	11	1,610	7	1,240
Asia:				
China	106	55,700	23	36,000
Hong Kong	1	375	(3)	267
Japan	1,200	50,100	396	15,500
Korea, Republic of	22	4,490	9	2,950
Singapore	1	776	1	966
Taiwan	3	1,660	4	1,210
Other	(3)	1,010	4	984
Total	1,340	114,000	437	57,800
Europe:				
Belgium	23	10,600	3	1,640
Germany	39	16,800	34	19,800
Italy	2	751	1	700
Netherlands	145	7,000	52	4,260
Russia	(3)	39	(3)	20
United Kingdom	4	4,800	5	2,430
Other	46	12,100	5	10,700
Total	259	52,000	100	39,500
North America:				
Bahamas, The	(3)	77	(3)	82
Canada	1,010	54,700	1,150	43,200
Mexico	417	19,000	420	22,600
Trinidad and Tobago	1	211	1	410
Other	5	1,530	5	1,260
Total	1,440	75,500	1,580	67,500
Oceania:				
Australia	2	1,050	2	993
New Zealand	(3)	85	(3)	69
Other	1	204	--	--
Total	3	1,340	2	1,060
South America:				
Argentina	26	7,810	17	3,390
Brazil	4	850	3	1,480
Colombia	1	391	4	1,650
Peru	21	4,620	2	445
Venezuela	2	1,070	(3)	264
Other	1	444	2	418
Total	55	15,200	28	7,640
Grand total	3,100	260,000	2,150	175,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship value of material at U.S. port of export. Based on transaction price, includes all charges incurred in placing material alongside ship.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF INDUSTRIAL SAND, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

Country	2008		2009	
	Quantity	Value[2]	Quantity	Value[2]
Australia	2	1,030	(3)	567
Canada	244	15,900	88	4,170
Chile	1	374	(3)	62
China	(3)	173	(3)	160
Germany	(3)	384	(3)	143
Japan	(3)	29	(3)	47
Mexico	103	3,590	5	2,540
Netherlands	(3)	134	(3)	30
Norway	(3)	48	--	--
Other	5	1,830	1	372
Total	355	23,500	95	8,080

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight value of material at U.S. port of entry. Based on purchase price; includes all charges (except U.S. import duties) in bringing material from foreign country to alongside carrier.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 10

INDUSTRIAL SAND AND GRAVEL (SILICA): WORLD PRODUCTION, BY COUNTRY[1,2]

(Thousand metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Argentina	461	446	457[r]	473[r]	450
Australia[e]	5,169[4]	5,200	5,300	5,300	5,200
Austria	1,610	2,008	1,890[r]	2,150[r]	1,500
Belgium[e]	1,800	1,800	1,800	1,800	1,800
Belize[e]	18[4]	11	12	12	12
Bosnia and Herzegovina	120[r]	711[r]	671[r]	702[r]	700
Brazil, silex[e]	2[r]	2[r]	2[r]	2	2
Bulgaria	583[r]	250[r]	551[r]	734[r]	650
Canada, quartz	1,466	2,146	1,987	1,979	1,296[4]
Chile	1,151	1,081	1,234	1,401	1,405[4]
Croatia	131[r]	140[r]	148[r]	150[r,e]	150
Cuba[e]	14	9	21[r]	29[r]	30
Czech Republic, foundry sand	807[r]	773[r]	850[r]	702[r]	1,364[4]
Denmark, sales[e]	60	60	60	60	60
Ecuador	38	36	36[e]	36[e]	36
Egypt[e,5]	650	650	1,725[r,4]	1,612[r,4]	1,750
Eritrea[e]	(6)	(6)	(6)	(6)	(6)
Ethiopia[e,7]	5[r]	6[r]	6[r,4]	7[r,4]	7
Finland	2,860[r]	3,003[r]	2,958[r]	3,160[r]	2,241[4]
France[e]	5,100[4]	5,000	5,000	5,000	5,000
Gambia[e]	1,390	1,390	712[r,4]	1,065[r,4]	1,100
Germany	7,681	7,703	8,382	8,186	6,453[4]
Greece[e]	100	100	100	65[r,4]	38[4]
Guatemala	(6)	58	68	65[r]	36[4]
Hungary	138[r]	120[r]	117[r]	100[r,e]	290
Iceland[e]	4	4	4	4	4
India[e]	1,600	1,600	1,600	1,700	1,700
Indonesia[e]	132	135	135	138	138
Iran[8]	1,900	1,900	2,000[e]	2,000[e]	1,500
Ireland[e]	5	5	5	5	5
Israel	196	204	220	147[r]	150
Italy	14,400	13,800	13,800[e]	13,800[e]	13,800
Jamaica	14	10	14	15[r]	7[4]
Japan	4,549	4,593	4,314	3,664[r]	3,500
Jordan	229	392	628	650[e]	700
Kenya[e]	34	34	34	34	34
Korea, Republic of	461	1,437	2,227[r]	1,757[r]	455[4]
Latvia	18	13	13[e]	12[e]	12
Lithuania	47	43[r]	45	38[r]	41[4]
Malaysia	532	512	719	1,467[r]	161[p,4]
Mexico	2,121	2,662	2,700[e]	2,779	2,770
Netherlands[e]	5	5	5	5	5
New Caledonia[e]	40	40	40	40	40
New Zealand	65	59	86	49[r]	50
Nigeria	--	--	--	26	32[4]
Norway[e]	1,600	1,500	1,500	1,500	1,500
Paraguay[e]	25	25	25	25	25
Peru[e]	900	900	900	900	900
Philippines	224	179	141[r]	172[r]	185[4]
Poland	3,270	3,850	4,000[e]	4,000[e]	4,385[4]
Portugal[e]	5	5	5	5	5
Romania	475	522	520[e]	520[e]	520

See footnotes at end of table.

TABLE 10—Continued

INDUSTRIAL SAND AND GRAVEL (SILICA): WORLD PRODUCTION, BY COUNTRY[1,2]

(Thousand metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Saudi Arabia	--	--	--	799	--
Serbia[e]	260[9]	260	260	260	260
Slovakia[e]	2,000	2,000	2,000	2,000	620
Slovenia[e]	200	200	200	200	200
South Africa	2,671	3,231	3,352[r]	3,544[r]	2,306[4]
Spain[e]	5,100	5,100	5,000	5,000	5,000
Sri Lanka	--	46	70	61	60[4]
Sweden[e]	700	700	700	700	700
Thailand	718	862	844[r]	496[r]	600
Turkey	1,467[r]	1,872[r]	2,147[r]	2,100[r,e]	1,250
United Kingdom	5,200	5,600	5,600[e]	5,600[e]	5,600
United States, sold or used by producers	30,600[r]	28,900	30,100	30,400	24,600[4]
Venezuela[e]	207[4]	500	500	500	500
Zimbabwe[10]	1	1[e]	--	--	--
Total	113,000[r]	116,000[r]	120,000[r]	122,000[r]	106,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 17, 2009.

[3] In addition to the countries listed, Angola, Antigua and Barbuda, The Bahamas, China, countries of the Commonwealth of Independent States, and Iraq produce industrial sand, but current available information is inadequate to formulate reliable estimates of output levels.

[4] Reported figure.

[5] Fiscal years beginning July 1 of that stated.

[6] Less than ½ unit.

[7] Ethiopian calender year ending July 7 of that stated.

[8] Fiscal years beginning March 21 of that stated.

[9] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[10] Includes rough and ground quartz as well as silica sand.

SILICON

By Lisa A. Corathers

Domestic survey data and tables were prepared by Maria Arguelles, statistical assistant.

In 2009, domestic ferrosilicon production decreased 23% from that of 2008 to 139,000 metric tons (t) of contained silicon (table 1). On a gross-weight basis, ferrosilicon production decreased by 25% from the revised amount of 307,000 t produced in 2008 (table 2). Domestic statistics for silicon metal were withheld to avoid disclosing company proprietary data. On the basis of contained silicon, U.S. exports of silicon products increased by 3%, and imports decreased by 49%. The increase in exports was primarily associated with an increase in the "more than 99.99% silicon" metal trade category (table 5). The decrease in imports was primarily attributable to decreases in the "55% to 80%, other" ferrosilicon and the "99.00% to 99.99%" and "other" silicon metal trade categories (table 6). Apparent consumption for ferrosilicon decreased by 38% compared with that in 2008. Year-average import prices for the 50% and 75% ferrosilicon grades each decreased by 34% and 37%, respectively, and those for silicon metal decreased by 28% compared with that in 2008 (table 1).

Silicon is a light chemical element with metallic and nonmetallic characteristics. Silicon is rarely found free in nature. Silicon combines with oxygen and other elements to form silicates, which comprise more than 25% of the Earth's crust. Silica (SiO_2) as quartz or quartzite is used to produce silicon ferroalloys for the iron and steel industries and silicon metal for the aluminum and chemical industries. Silicon metal that is refined into semiconductor-grade metal for use in making computer chips is crucial to modern technology, but the quantity is less than 5% of total silicon metal demand (Roskill's Letter from Japan, 2000). Silicon metal may either be used directly in an upgraded metallurgical form or refined into wafers to power solar batteries. In order of amounts consumed, world consumption of silicon metal used to produce monocrystalline and polycrystalline silicon, amorphous monocrystalline silicon, and ribbon silicon solar cells in 2009 was estimated to be 74,000 t, which was about 5.7% of the total amount of silicon metal consumed worldwide [1.3 million metric tons, (Mt)] (Roskill's Letters from Japan, 2010b; c, p. 11). The U.S. Geological Survey (USGS) does not survey the high-purity silicon industry for production and related data; therefore, the only information that this report contains about these high-purity grades is as it appears in the foreign trade statistics and from published sources.

Production

Silicon Ferroalloys.—Domestic production data for silicon ferroalloys are derived from monthly and annual voluntary surveys and estimates for nonrespondents by the USGS. The data in table 2 were obtained from all operations listed in table 3 that are canvassed by means of the USGS "Silicon Alloys" survey. In terms of gross weight and compared with that of 2008, domestic ferrosilicon gross production and net shipments decreased by 25% and 19%, respectively. Producer stocks of ferrosilicon at yearend 2009 had decreased by 78% compared with those at yearend 2008. Data for ferrosilicon reflected adjustments in inventory and in-plant consumption of ferrosilicon to produce magnesium ferrosilicon and other miscellaneous alloys.

Silicon Metal.—Production-related statistics for silicon metal were withheld to avoid disclosing company proprietary data. In November, Globe Specialty Metals, Inc. (GSM; owner of U.S.-based silicon producer Globe Metallurgical, Inc.) formed a joint venture with Dow Corning Corporation—WVA Manufacturing LLC—at its 67,000-metric-ton-per-year (t/yr) silicon metal facility in Alloy, WV. GSM retained 51% ownership in, and operational control of, the plant; production would be split proportionally between the two companies. Also in November, GSM reopened its 30,000-t/yr silicon metal plant in Niagara Falls, NY (Globe Specialty Metals, Inc., 2009a, b).

Upgraded-Metallurgical-Grade Silicon Metal.—Upgraded-metallurgical-grade silicon metal (UMG-Si) is used in silicon-based photovoltaic (solar) cells. UMG-Si does not require as much additional refinement as does polycrystalline silicon, which has been traditionally used in solar panel wafers. Sometime in 2009, GSM suspended operations at its 360-t/yr Solsil UMG-Si plant in Beverly, OH. This loss was to be more than offset by GSM's 4,000-t/yr UMG-Si production capacity planned at its Niagara Falls silicon plant (Globe Specialty Metals, Inc., 2009b; 2010, p. 22).

Semiconductor- and Solar-Battery-Grade Silicon.—U.S. production capacity for polycrystalline silicon used in semiconductor and solar cells was reported to be 48,000 t in 2009. Total annual domestic polycrystalline production capacity by company was as follows: Hemlock Semiconductor Corp., 27,500 t; REC Group (includes REC Advanced Silicon Materials LLC and REC Solar Grade Silicon LLC), 11,000 t; MEMC Electronic Materials, 8,000 t; and Mitsubishi Materials Group, 1,500 t (Roskill's Letters from Japan, 2010a, p. 8).

Consumption

Silicon Ferroalloys and Metal.—Most ferrosilicon (including miscellaneous silicon alloys) was used to produce steel (68%) (table 4). Silicon metal was used mainly to produce chemicals—silanes, silicones, and others—and silica fume (78%). Silicon metal production at one U.S. silicone producer, Dow Corning, was reported to be between 100,000 to 110,000 t/yr of silicon metal at its 260,000-t/yr plant in Carrollton, KY (Louisville & Jefferson County Riverport Authority, 2008, p. 45, 51).

Metallurgical-grade silicon carbide can substitute for ferrosilicon, especially in iron foundries. Data on North American production and U.S. imports of silicon carbide are reported in the Manufactured Abrasives chapter of the 2009 USGS Minerals Yearbook, volume I, Metals and Minerals.

In 2009, apparent consumption of ferrosilicon and miscellaneous silicon alloys decreased 38% to 217,000 t compared with that of 2008 (table 1). Decreases in net imports for consumption contributed to the decline in ferrosilicon apparent consumption. Silicon metal apparent consumption was withheld to avoid disclosing company proprietary data.

Reported consumption of ferrosilicon, which includes miscellaneous silicon alloys, was 59% of apparent consumption (content basis). This percentage was derived based on the typical silicon content of these materials noted in table 4.

Consumption of ferrosilicon and silicon metal was estimated by CRU International Ltd. to have each decreased in 2009 throughout the Western World. In terms of contained silicon, ferrosilicon consumption decreased to 1.38 Mt in 2009 from 2.10 Mt (revised) in 2008, and silicon metal consumption decreased to 1.03 Mt from 1.48 Mt. Areas with the largest year-to-year decrease in consumption of ferrosilicon were Europe, Asian countries (excluding China, Japan, and North Korea), and the United States. Areas with the largest year-to-year decrease in consumption of silicon metal were the European Union (EU) and Asian countries (excluding China, Japan, and North Korea). In decreasing order of consumption, Europe, other Asian countries (excluding China, Japan, and North Korea), and Japan accounted for 70% of the ferrosilicon consumption in 2009. Also in decreasing order of consumption, the EU, the United States, and Japan accounted for 73% of the silicon metal consumed in 2009 (CRU Bulk Ferroalloys Monitor, 2010a, b).

Prices

Ferrosilicon and silicon metal prices (excluding those of ultra high-purity silicon) tend to vary in response to changes in supply and demand by the steel, ferrous foundry, chemical, and aluminum industries. There were significant decreases in silicon material prices in 2009 from those in 2008 because of continued effects of the economic downturn that began during the third quarter 2008. The year-average spot prices given by Platts Metals Week were 68.9 cents per pound for 75% ferrosilicon and 116.3 cents per pound for silicon metal; these prices were 37% and 28% lower, respectively, than those of 2008. The year-average North American transaction price for 50% ferrosilicon as calculated from Ryan's Notes listings was 76.9 cents per pound, a 34% decrease from that of 2008. Average monthly ferrosilicon spot prices were at their lowest in April 2009—62.5 cents per pound for 50% ferrosilicon and 53.8 cents per pound for 75% ferrosilicon—before trending upward throughout the rest of the year. The average monthly silicon metal price started the year at a high of 137.5 cents per pound, and hit a low of 104.5 cents per pound in early August before rising again. The range for spot market prices, in cents per pound, ended the year as follows: silicon metal, 112 to 117; 50% ferrosilicon, 87 to 90; and 75% ferrosilicon, 76 to 78.

Foreign Trade

Trade volumes discussed are based on gross weight. U.S. ferrosilicon exports decreased by 20% to 14,200 t, and their value decreased by 43% to $16.8 million from those of 2008. In decreasing order of quantity, Canada and Mexico accounted for 84% of the total 2009 ferrosilicon exports (table 5). Exports of silicon metal increased by 7% to 37,900 t, but their value decreased by 8% to $2.07 million from that of 2008. In decreasing order of quantity, Japan, China, and Germany accounted for 68% of silicon metal exports. Shipments of high-purity silicon containing more than 99.99% silicon accounted for 84% of total silicon metal exported and 99% of the total value of combined ferrosilicon and silicon metal exports.

U.S. ferrosilicon imports decreased by 63% to 103,000 t, and the value of those imports decreased by 68% to $126 million compared with that in 2008. These imports declined primarily because of a decrease in the “55% to 80% silicon, other” ferrosilicon trade category. Imports of standard 75% ferrosilicon (ferrosilicon category of “55% to 80% silicon, other”) accounted for 78% of total ferrosilicon imports by gross weight and 75% of total ferrosilicon value (table 6). Russia was the leading source of ferrosilicon imports at 45%, followed by Canada (20%) and China (14%).

Silicon metal imports (116,000 t) decreased by 33% from those in 2008, and decreased by 30% in value to $477 million from $678 million in 2008. The decrease in silicon metal imports was attributable to decreases in the “99.00% to 99.99% silicon” (41,900 t) and “silicon, other” (14,900 t) trade categories. Brazil was the leading source of “99.00% to 99.99% silicon” silicon metal imports at 36%, followed by South Africa at 23% and Australia at 15%. Canada was the leading source of “silicon, other” silicon metal imports at 38%, followed by Brazil at 26% and Norway at 12%. Silicon metal in the “99.00% to 99.99% silicon” trade category accounted for 88% of the quantity, and 54% of the value, respectively, of all silicon metal imported in 2009. The quantity of silicon metal imports in this trade category decreased by 29% compared with that of 2008.

The estimated U.S. net import reliance for ferrosilicon in 2009 as a percentage of apparent consumption decreased to 38% from 49% (revised) in 2008. Silicon metal import reliance was withheld to avoid disclosing company proprietary data.

The general rates of duty that applied to U.S. imports during 2009 were the same as those in 2008. These were, on an ad valorem basis, 5.8% for ferrosilicon containing more than 90% silicon; 5.3% or 5.5% for metal containing 99.00% to 99.99% silicon or “other” silicon, respectively; 1.9% for ferrosilicon containing 80% to 90% silicon; 1.5% for standard 75% ferrosilicon; 1.1% for nominal 75% ferrosilicon that contains more than 3% calcium; and free for magnesium ferrosilicon, metal containing more than 99.99% silicon, and other ferrosilicon (U.S. International Trade Commission, 2009).

Antidumping Duty Administrative Reviews.—There were no final antidumping duty rates assessed in 2009 on imports of silicon materials to the United States. Results of appeals of import antidumping duty reviews made in 2009 are found in table 7.

Foreign-Trade Zone Designation.—The Foreign-Trade Zones Board of the U.S. Department of Commerce granted foreign-trade zone (FTZ) subzone status to Shin-Etsu Handotai America, Inc.'s semiconductor-grade silicon wafer manufacturing plant in Vancouver, WA. With this FTZ status, Shin-Etsu Handotai would be allowed to import silicon metal duty free provided that all of it be reexported whether manufactured into a downstream product or not (U.S. Department of Commerce, Foreign-Trade Zones Board, 2009).

U.S.-World Trade Organization (WTO) Chinese Raw Material Export Dispute Settlement Proceedings.—On June 23, the United States requested consultations with China and the WTO Dispute Settlement Body (DSB) about curbs placed by China on exports of various materials, including silicon metal. In July, Canada, the EU, Mexico, and Turkey requested to join the consultations. On November 4, the Office of the United States Trade Representative requested that the DSB establish a dispute settlement panel to review the U.S. claims. (The European Union and Mexico also requested the establishment of a dispute settlement panel.) The DSB established a single panel on December 21 and appointed panel representatives on March 29, 2010. The panel was expected to finalize the proceedings in April 2011 (Office of the United States Trade Representative, 2009; World Trade Organization Dispute Settlement Body, 2010).

World Industry Structure

Data on annual world production of ferrosilicon and silicon metal by country from 2005 through 2009 are provided in the Ferroalloys chapter of the 2009 USGS Minerals Yearbook, volume I, Metals and Minerals. World production of ferrosilicon, on a gross-weight basis, was estimated to have been 7.43 Mt in 2009 compared with 7.37 Mt (revised) in 2008. The major ferrosilicon producers in 2009 were, in decreasing order, China, Russia, Norway, the United States, and Ukraine; they accounted for 87% of total world production listed in table 1.

World production of silicon metal, excluding that from the United States, was estimated to have been 1.49 Mt in 2009 compared with 1.63 Mt (revised) in 2008 (table 1). China was by far the leading producer of silicon metal in the world in 2009 with an estimated 950,000 t; this was 64% of the world total. Other major producers of silicon metal in 2009 were, excluding the United States and in decreasing order, Norway and Brazil; they accounted for 20% of world production reported in table 1. New ferrosilicon and silicon metal projects scheduled for completion around the world from 2009 through 2013 are listed in table 8.

World Review

European Union.—In December, the Council of the European Union repealed the 5.4% antidumping duty on ferrosilicon imports from Macedonian producer Silmak dooel that was imposed in February 2008 (Official Journal of the European Union, 2009).

Brazil.—GSM sold its Globe Metais SA silicon metal plant in Brue Branco to Dow Corning in November. The plant production capacity was 43,600 t/yr (Globe Specialty Metals, Inc., 2009a).

Canada.—Timminco Limited reported UMG-Si production was negatively impacted in 2009 because of low demand from customers, higher overheads related to expanded production capacity, and UMG-Si byproduct recycling during the first half of the year. As a result, four of seven purification lines were shut down in May and two more lines were closed in July. The seventh line was shut down in January 2010 pending recovery in the solar market.

Timminco also reported that its Becancour Silicon Inc. plant in Becancour, Quebec, had a nominal silicon metal production capacity of about 50,000 t/yr using three electric arc furnaces. During the first and second quarters of 2009, the plant produced silicon metal for both internal (UMG-Si production) and external consumption. The plant was shut down in May owing to low demand by the aluminum and chemical industries. However, between June and November, all three furnaces were restarted based on improving market conditions (Timminco Limited, 2010, p. 26).

China.—China's exports of silicon materials in 2009 were affected by the global economic downturn that started in the third quarter of 2008, continued high export tariffs, and increased electricity fees imposed by the Central Government of China in late November 2009. China's exports of ferrosilicon fell 65% from those of 2008 to about 447,000 t (TEX Report, The, 2010c). China's exports of silicon metal were also significantly less in 2009 compared with those in 2008; they were down 39% to 421,669 t from 692,711 t (Metal Pages, 2010).

The Chinese export tariffs in 2009 for ferrosilicon and silicon metal remained at 25% and 15%, respectively (Metal Pages, 2009a). With these duties, the Chinese Government aimed to reduce exports of these materials from the country so more material would be available for the domestic market.

The Central Government of China raised the country's electricity fees on average by USD0.004 (CNY0.028) per kilowatthour (kwh) effective November 20. However, the increase in electricity fees was higher at USD 0.013 (CNY0.088) per kwh in the so-called Silicon Land—the area comprised of the Gansu Province, Inner Mongolia Autonomous Region, and Ningxia Hui Autonomous Region (TEX Report, The, 2010b).

China's largest ferroalloys producer, Erdos Group, produced 490,000 t of ferrosilicon, 20,000 t of silicon metal, and 1.3 Mt of silicon carbide in 2009 (TEX Report, The, 2010a).

France.—After operating its French silicon smelters from April through October, Grupo FerroAtlántica S.L. (Ferroatlantica) suspended operations again in November for 5 months citing a slow recovery in demand from the aluminum and chemical markets. As a result, French silicon metal production was 40% lower in 2009 than in 2008. The plants that were affected included the following with their associated products and capacities: Anglefort, silicon metal (36,000 t/yr); Château Feuillet, silicon metal (12,000 t/yr); Laudun, ferrosilicon (25,000 t/yr) and silicon (14,000 t/yr); Les Clavaux, silicon metal (35,000 t/yr); and Montricher, silicon metal (30,000 t/yr) (Grupo FerroAtlántica, S.L., 2010; Metal Pages, 2009b, c).

Japan.—Japan relied on imports of ferrosilicon and nonsemiconductor and solar-battery-grade silicon metal (< 99.999 silicon content) to meet its silicon material requirements in 2009. Japan imported 294,000 t of ferrosilicon, which was one-half that of 2008. This was a result of decreased demand by the Japanese steel industry and a surplus of ferrosilicon stocks from 2008 imports. According to United Nations trade statistics, Japan imported about 165,000 t of silicon metal in 2009. This was 36% less than in 2008 and was attributed to decreased consumption by the aluminum, chemical, and electronics industries (TEX Report, The, 2010d).

Kazakhstan.—Eurasian Natural Resources Corporation PLC produced 43,000 t of ferrosilicon in 2009. Most of the production was at its Aksu plant in Kazakhstan supplemented by some from its recently acquired Serov plant in Russia (Eurasian Natural Resources Corporation PLC, 2008, 2009, and 2010).

Macedonia.—Silmak dooel resumed production at its ferrosilicon plant in Jegunovce after a 4-month shutdown in early 2009 before shutting down again in early November. The plant has seven EAFs capable of producing 80,000 t/yr (Ryan's Notes, 2009a; Thefreelibrary.com, 2009).

Norway.—Elkem AS (2009a, b) announced it would restart two furnaces in the third quarter of 2009—one furnace at its Bremanger ferrosilicon plant and one at its Salten silicon metal plant—because of improved market conditions. Elkem had total ferrosilicon production capacity of 76,000 t/yr; 40,000 t/yr at the Bjolvefossen plant and 36,000 t/yr in Bremanger. Elkem's silicon metal capacity was as follows: Bremanger, 28,000 t/yr; Salten, 65,000 t/yr; and Thamshavn, 40,000 t/yr.

Fesil AS' production of silicon materials was impacted in 2009 by the global economic downturn. The company reported full capacity utilization at its 2-furnace Rana Metall ferrosilicon plant until May, when capacity utilization dropped to about 50% for the rest of the year. At its Holla Metall silicon metal plant, three of four furnaces were closed in the first quarter of 2009, and only two furnaces produced intermittently thereafter. The Rana Metall ferrosilicon plant production capacity was 90,000 t/yr, and the Holla Metall silicon metal plant production capacity was 50,000 t/yr (Fesil AS, 2010, p. 11–12, 15–16).

Russia.—Mechel OAO reported a 6% decrease in ferrosilicon production at its Bratsk ferroalloys plant to 86,010 t in 2009 from 91,900 t in 2008. The company planned to increase the plant's annual ferrosilicon production capacity to about 96,000 t by 2012 (Mechel OAO, 2010, p. 101–102, and 104).

South Africa.—Silicon Smelters (a subsidiary of Spanish ferroalloy producer Ferroatlantica's FerroPem division) operated two of three silicon metal furnaces. As a result, silicon metal production in 2009 was 25% less than that of 2008 (Ryan's Notes, 2009b).

Spain.—During the year, Ferroatlantica operated only one furnace intermittently at its Sabon silicon metal plant. As a result, the company was expected to produce no more than 20% of its total production capacity (40,000 t/yr) (Metal Pages, 2009b; Grupo FerroAtlántica, S.L., 2010).

Ukraine.—Ferrosilicon production in the Ukraine decreased slightly to 150,300 t from 152,800 t in 2008. Stakhanov Ferroalloy Works produced 111,000 t of ferrosilicon, up 35.4% from that of 2008, and Zaporizhiya Ferroalloy Works produced 39,300 t of ferrosilicon, down 32.2% from that of 2008 (Interfax Russia & CIS Metals & Mining Weekly, 2010).

Outlook

Consumption of ferrosilicon follows trends in the iron and steel industries, for which the combined annual growth rates (CAGRs) have been typically in the range of 1% to 2% in the United States. Details of the outlook for the steel industry are discussed in the Outlook section of the Iron and Steel chapter of the 2009 USGS Minerals Yearbook, volume I, Metals and Minerals. According to the World Steel Association (2009), raw steel production, compared with that in 2008, decreased by 36.4% to 58.1 Mt in the United States while decreasing 8% worldwide to 1,220 Mt. However, raw steel production in China, the leading world producer of raw steel, increased by 13.5% to about 568 Mt. MEPS (International) Ltd. (2010) forecast world raw steel production would increase to 1.4 billion metric tons in 2010 from that in 2009, with a 21% increase in North American raw steel production to 100.5 Mt.

Demand for silicon metal comes primarily from the aluminum and chemical industries. Consumption of silicon metal by the U.S. aluminum castings industry was expected to mirror the short-term growth rate of 29% from 2009 (1.313 Mt) through 2011 (1.695 Mt) in aluminum casting shipments, and the long-term growth rate of 6.1% annually from 2011 through 2019 (2.37 Mt) (Kirgin, 2010). U.S. chemical production was expected to increase by 3.1% in 2010 (by 5.2% when excluding pharmaceuticals) compared with that in 2009. Domestic chemical production was expected to rise by 3% in 2011 (by 2.7% if pharmaceuticals are excluded) compared with 2010 (Bomgardner, 2011).

World production capacity for polycrystalline silicon can be used as a rough indicator of high-purity silicon consumption. Compared with that of 2008, world polycrystalline silicon output increased by 40% to 80,000 t in 2009. Of that amount, consumption in solar cells rose by 76% to 60,000 t in 2009 compared with that of 2008, while use in semiconductors declined by 13% to 20,000 t. World production capacity for polycrystalline silicon was forecast to increase by 54% to 141,800 t in 2010 from 92,100 t in 2009; by 2013, world polycrystalline silicon production capacity would increase to 195,500 t (Roskill's Letters from Japan, 2010a, p. 6, 8).

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TABLE 1

SALIENT SILICON STATISTICS[1]

(Contained silicon, unless otherwise noted)

		2005	2006	2007	2008	2009
United States production:						
Ferrosilicon	thousand metric tons	125	146	155	180 r	139
Silicon metal	do.	145	W	W	W	W
Exports:						
Ferrosilicon	do.	8	5	7	10	9
Silicon metal	do.	23	27	28	35	38
Imports for consumption:						
Ferrosilicon	do.	197	223	208	190	70
Silicon metal	do.	152	146	147	168	113
Apparent consumption:						
Ferrosilicon	do.	317	363	359	352 r	217
Silicon metal	do.	275	W	W	W	W
Price, average:						
Ferrosilicon, 50% Si[2]	cents per pound	55.00	62.93	73.96	115.86	76.93
Ferrosilicon, 75% Si[3]	do.	48.03	54.87	65.62	108.71	68.91
Silicon metal[4]	do.	76.18	79.29	112.69	162.29	116.37
World production, gross weight:						
Ferrosilicon	thousand metric tons	5,810 r	6,490 r	7,330 r	7,370 r	7,430
Silicon metal	do.	1,540 r	1,470 r, 5	1,560 r, 5	1,630 r, 5	1,500 5

r Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Ryan's Notes North American transaction prices based on weekly averages.

[3] Platts Metals Week mean import prices based on monthly averages.

[4] Platts Metals Week dealer import prices based on monthly averages.

[5] Excluding the United States.

TABLE 2

PRODUCTION, SHIPMENTS, AND STOCKS OF SILICON ALLOYS AND METAL IN THE UNITED STATES[1, 2]

(Metric tons)

	Silicon content (percent)		2008 producers' stocks, December 31 (gross weight)	2009		
Material	Range	Typical		Gross production[3] (gross weight)	Net shipments (gross weight)	Producers' stocks, December 31 (gross weight)
Ferrosilicon[4]	25–65 5	48	15,200 r	124,000	98,000	5,180
Do.	56–95	76	18,400 r	105,000	96,800	2,190
Silicon metal, excluding semiconductor grades	96–99	98	W	W	W	W

r Revised. Do. Ditto. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Data for silvery pig iron (less than 25% silicon) withheld to avoid disclosing company proprietary data.

[3] Ferrosilicon production includes material consumed in the production of miscellaneous silicon alloys.

[4] Includes miscellaneous silicon alloys, which were listed separately prior to 1999.

[5] 25% to 55% for ferrosilicon; 32% to 65% for miscellaneous silicon alloys.

TABLE 3
PRINCIPAL PRODUCERS OF SILICON ALLOYS AND (OR) SILICON METAL IN THE UNITED STATES IN 2009

Producer	Plant location	Product
CC Metals and Alloys, Inc.	Calvert City, KY	Ferrosilicon.
Globe Metallurgical, Inc.[1]	Alloy, WV	Ferrosilicon and silicon metal.
Do.	Beverly, OH	Do.
Do.	Niagara Falls, NY[2]	Silicon metal.
Do.	Selma, AL	Do.
Core Metals Group[1]	Bridgeport, AL	Do.
Simcala, Inc.	Mt. Meigs, AL	Silicon metal.

Do. Ditto.

[1] Owned by Globe Specialty Metals.

[2] The Niagara Falls plant reopened in November 2009.

TABLE 4
REPORTED CONSUMPTION, BY END USE, AND STOCKS OF SILICON FERROALLOYS AND METAL IN THE UNITED STATES IN 2009[1, 2]

(Metric tons, gross weight)

End use	Silvery pig iron[3]	Ferrosilicon, 50%[4]	Ferrosilicon, 75%[5]	Silicon metal[6]	Miscellaneous silicon alloys[7]	Silicon carbide[8]
Steel:						
Carbon and high-strength, low-alloy	(9)	(10)	27,600	(11)	828	(10)
Stainless and heat-resisting	--	(10)	40,800	294	(10)	(10)
Full alloy	--	5,050	6,290	(11)	(10)	--
Electric and tool	--	--	(10)	--	--	(10)
Unspecified	--	24,400	26,400	(11)	277	5,860
Total	--	29,500	101,000	294	1,110	5,860
Cast irons	3,870	27,600	20,800	(11)	13,000	22,900
Superalloys	--	(9)	(11)	(11)	(11)	--
Alloys, excluding superalloys and alloy steel	(9)	(9)	(11)	50,800 [12]	--	--
Miscellaneous and unspecified	--	(9)	651	179,000 [13]	(9)	(9)
Grand total	3,870	57,000	123,000	230,000	14,100	28,800
Consumers' stocks, December 31	371	1,480	7,620	2,320	657	1,160

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes U.S. Geological Survey estimates.

[3] Typically 18% silicon content but ranges between 5% to 24% silicon content.

[4] Typically 48% silicon content but ranges between 25% to 55% silicon content; includes briquets.

[5] Typically 76% silicon content but ranges between 56% to 95% silicon content; includes briquets.

[6] Typically 98% silicon content but ranges between 96% to 99% silicon content.

[7] Typically 48% silicon content. Primarily magnesium-ferrosilicon but also includes other silicon alloys.

[8] Typically 64% silicon content but ranges between 63% to 70% silicon content. Does not include silicon carbide for abrasive or refractory uses.

[9] Included with "Cast irons," to avoid disclosing company proprietary data.

[10] Included with "Steel: Unspecified," to avoid disclosing company proprietary data.

[11] Included with "Miscellaneous and unspecified," to avoid disclosing company proprietary data.

[12] Primarily aluminum alloys.

[13] Primarily silicones, fumed silica, and other chemicals.

TABLE 5
U.S. EXPORTS OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2009[1]

Country	Gross weight (metric tons)	Contained weight (metric tons)	Value
Ferrosilicon:			
More than 55% silicon:			
Brazil	40	24	$60,800
Canada	7,750	5,070	6,190,000
Colombia	50	41	132,000
France	25	19	40,400
Germany	40	31	54,300
Japan	138	105	183,000
Malaysia	23	17	44,000
Mexico	2,190	1,440	3,560,000
Netherlands	83	63	122,000
United Kingdom	152	100	148,000
Others (7 countries)	64	47	120,000
Total	10,600	6,950	10,700,000
Other ferrosilicon:			
Belgium	319	160	592,000
Canada	1,100	550	1,740,000
Egypt	100	46	210,000
Germany	118	59	174,000
Japan	86	22	100,000
Korea, Republic of	342	152	243,000
Mexico	869	384	1,690,000
Portugal	80	37	152,000
Spain	200	99	391,000
Turkey	189	85	343,000
Other (8 countries)	247	122	568,000
Total	3,650	1,720	6,200,000
Grand total ferrosilicon	14,200	8,670	16,900,000
Metal			
More than 99.99% silicon:			
Canada	98	98	4,910,000
China	7,890	7,890	490,000,000
Germany	4,950	4,950	251,000,000
Hong Kong	249	249	15,300,000
Italy	99	99	6,970,000
Japan	10,500	10,500	717,000,000
Korea, Republic of	1,860	1,860	149,000,000
Malaysia	151	151	17,800,000
Norway	3,960	3,960	249,000,000
Taiwan	1,560	1,560	109,000,000
Other (41 countries)	509	509	46,900,000
Total	31,800	31,800[2]	2,060,000,000
99.00%–99.99% silicon:			
Belgium	240	238	691,000
China	410	406	1,180,000
Germany	49	49	69,500
Italy	100	99	194,000
Japan	71	71	159,000
Mexico	52	52	117,000
Netherlands	242	241	466,000
Singapore	83	82	156,000
Taiwan	204	203	544,000
United Kingdom	167	166	329,000

See footnotes at end of table.

TABLE 5—Continued
U.S. EXPORTS OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2009[1]

Country	Gross weight (metric tons)	Contained weight (metric tons)	Value
Metal—Continued			
Other	224	222	$434,000
Total	1,840	1,830	4,340,000
Other silicon:			
Canada	98	95	235,000
China	309	300	653,000
Germany	298	290	515,000
Hong Kong	373	362	492,000
Japan	1,330	1,290	2,850,000
Korea, Republic of	223	216	160,000
Netherlands	220	214	247,000
Philippines	93	90	158,000
Taiwan	743	721	1,470,000
United Kingdom	200	196	403,000
Other	305	296	851,000
Total	4,200	4,070	8,030,000
Grand total silicon metal	37,900	37,700	2,070,000,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Contained weight estimated from gross weight.

Source: U.S. Census Bureau.

TABLE 6

U.S. IMPORTS FOR CONSUMPTION OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2009[1]

Country	Gross weight (metric tons)	Contained weight (metric tons)	Value
Ferrosilicon:			
55%–80% silicon, more than 3% Ca:			
Argentina	116	70	$326,000
Brazil	449	274	611,000
Canada	21	13	32,100
China	817	567	1,040,000
France	225	137	704,000
Germany	18	12	46,800
Total	1,650	1,070	2,760,000
55%–80% silicon, other:			
Brazil	2,070	1,560	2,370,000
Canada	9,400	6,960	18,300,000
China	8,400	6,350	9,360,000
Egypt	518	383	580,000
France	1,140	803	3,170,000
Germany	250	177	1,450,000
India	55	41	169,000
Russia	46,300	35,500	44,600,000
South Africa, Republic of	320	230	378,000
Venezuela	12,200	9,150	14,300,000
Other (3 countries)	90	64	328,000
Total	80,800	61,200	95,000,000
80%–90% ferrosilicon:			
Germany	19	14	91,700
Norway	1	1	3,170
Total	20	15	94,800
Magnesium ferrosilicon:			
Argentina	468	188	1,460,000
Brazil	2,080	963	3,430,000
Canada	6,290	2,870	12,500,000
China	1,530	818	1,920,000
France	704	273	970,000
Germany	15	10	25,200
India	2	1	3,340
Japan	31	14	121,000
South Africa, Republic of	17	8	29,600
Total	11,100	5,150	20,500,000
Other ferrosilicon:			
Brazil	534	222	700,000
Canada	4,500	1,200	5,560,000
China	4,080	560	1,270,000
France	18	9	39,600
Norway	19	9	41,900
Poland	41	15	104,000
Russia	152	71	138,000
Total	9,340	2,090	7,850,000
Grand total ferrosilicon	103,000	69,600	126,000,000

See footnotes at end of table.

TABLE 6—Continued
U.S. IMPORTS FOR CONSUMPTION OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2009[1]

Country	Gross weight (metric tons)	Contained weight (metric tons)	Value
Metal:			
More than 99.99% silicon:			
Canada	200	200	$7,650,000
China	85	85	2,380,000
Germany	1,690	1,690	118,000,000
Italy	224	224	12,700,000
Japan	252	252	28,100,000
Korea, Republic of	310	310	18,100,000
Norway	17	17	974,000
Russia	10	10	704,000
Spain	8	8	45,600
Taiwan	40	40	1,000,000
Other (12 countries)	19	19	5,990,000
Total	2,850	2,850 [2]	196,000,000
99.00%-99.99% silicon:			
Australia	15,500	15,500	38,700,000
Brazil	38,700	37,600	95,600,000
Canada	7,030	6,950	15,200,000
Japan	26	13	99,000
Laos	7,200	7,160	15,400,000
Norway	9,030	8,970	29,700,000
Philippines	525	521	1,090,000
South Africa, Republic of	23,500	23,300	59,000,000
Sweden	32	30	244,000
Ukraine	302	299	800,000
Other (1 country)	1	1	2,700
Total	102,000	100,000	256,000,000
Other silicon:			
Australia	969	951	2,750,000
Brazil	2,860	2,730	7,980,000
Canada	4,090	3,950	8,310,000
China	602	593	960,000
France	209	205	544,000
Japan	127	95	365,000
Norway	1,300	985	2,640,000
Philippines	134	131	220,000
South Africa, Republic of	117	96	234,000
Ukraine	318	314	801,000
Other (8 countries)	117	91	212,000
Total	10,800	10,100	25,000,000
Grand total silicon metal	116,000	113,000	477,000,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Contained weight estimated from gross weight.

Source: U.S. Census Bureau.

TABLE 7
SILICON MATERIALS: APPEALS OF IMPORT ANTIDUMPING DUTY ADMINISTRATIVE REVIEWS IN 2009, BY DECISION DATE

Imported material	Country of origin	Period of investigation	U.S. court	Decision	Decision date	Source
Silicon metal	China	6/1/05 – 05/31/06	CIT	Upheld ITA's use of Indian silicon dioxide import data as a surrogate value for silica fume in its remand determination to establish antidumping duties for two new Chinese shippers of silicon metal (Jiangxi Gangyuan Silicon Industry Co. Ltd. and Shanghai Jinneng International Trade Company Ltd.). As a result, ITA was expected to amend the antidumping duty rates of imports from the two companies.	May 5	Globe Metallurgical Inc. v. United States, et. al., Consol. Court No. 07–00386, CIT Slip Opinion 09–37.
Ferrosilicon	Brazil China Kazakhstan Russia Ukraine Venezuela	7/1/89 – 12/31/93	CAFC	Sustained the CIT's determination in September 2008 that U.S. ferrosilicon producers were not materially injured by these imports. As a result, no antidumping rates would be assessed.	May 11	CAFC Appeal No. 2009–1007, Elkem Metals Co., et. al., v. United States, et. al., Consol. Court No. 99–00628, CIT Slip Opinion 08–92.

CAFC, U.S. Court of Appeals for the Federal Circuit. CIT, Court of International Trade. ITA, the International Trade Administration of the U.S. Department of Commerce.

TABLE 8
SILICON MATERIALS: PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2013[1, 2, 3]

(Metric tons, gross weight, unless otherwise specified)

Projected year of first production	Country	Project and company	Project type	Incremental annual production capacity	Total annual production capacity	Silicon product[4]
2009	Brazil	Ferbasa Plant Cia de Ferro Ligas da Bahia (Ferbasa)	ferroalloys plant expansion	18,000	81,000	FeSi.
2009	China	ERDOS Qipanjing Plant ERDOS Group	do.	220,000 [e]	550,000	Do.
2010	Do.	do.	do.	100,000	650,000	Do.
2010	Do.	Henan Sunshine Silicon Plant Henan Sunshine Silicon Technology Development	silicon plant expansion	80,000	120,000	Si.
2010	Do.	Qinghai Wutong Plant Qinghai Wutong (Group) Industry Co., Ltd.	ferroalloys plant expansion	25,000	400,000	FeSi.
2010	Russia	Yurga Plant JSC[5] Kuznetsk Ferroalloys	do.	19,500	41,400	Do.
2011	Australia	Simcoa Silicon Plant Simcoa Operations Pty., Ltd.	silicon plant expansion	16,000	48,000	Si.
2011	China	Ferroatlantica Sichuan Silicon Plant Grupo Ferroatlántica, S.L.	new smelter	NA	50,000	Do.
2011	Do.	Qinghai Wutong Plant Qinghai Wutong (Group) Industry Co., Ltd.	ferroalloys plant expansion	25,000	450,000	FeSi.
2011	Russia	Yurga Plant JSC[5] Kuznetsk Ferroalloys	do.	41,400	80,000	Do.
2012	Australia	Simcoa Silicon Plant Simcoa Operations Pty., Ltd.	silicon plant expansion	16,000	64,000	Si.
2012	Zambia	Kafue Ferroalloys Plant Universal Mining and Chemical Industries Ltd. (Umcil)	new ferroalloys plant[6, 7]	NA	80,000	FeSi.
2013	China	Ferroatlántica Sichuan Silicon Plant Grupo Ferroatlántica, S.L.	new silicon smelter	50,000	100,000 [r]	Si.

[e] Estimated. [r] Revised. Do., do. Ditto. NA Not available.

[1] Estimated data are rounded to no more than three significant digits.

[2] Excludes silicon metal containing more than 99.99% silicon.

[3] Projects in feasibility or later stages of development in 2009. Actual startup dates may be postponed, owing to economic or other factors. Additional projects might produce silicon materials by 2014, but not enough information was available to include them.

[4] FeSi Ferrosilicon. Si Si metal (containing 99.99% or less Si).

[5] JSC joint-stock company.

[6] Plant also scheduled to produce ferromanganese and silicomanganese.

[7] Plant may also produce ferronickel.

Sources: Company annual reports, presentations, and press releases; unpublished personal communications; and trade publications.

SILVER

By William E. Brooks

Domestic survey data and tables were prepared by Shonta E. Osborne, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2009, the United States produced 1,250 metric tons (t) of silver, which was equal to 2008 domestic silver production and accounted for approximately 6% of world mine production of 21,800 t of silver. Silver was produced in 11 States in 2009, and Alaska remained the country's leading silver-producing State, followed by Nevada and Idaho. Approximately 99% of domestic silver was produced from base-metal ores at 12 mines and from precious-metal ores at 13 mines.

The price of silver averaged $14.69 per troy ounce in 2009, a slight decrease compared with the 2008 average price of $15.02 per troy ounce, according to Platts Metals Week. The price of silver peaked at $19.45 per troy ounce on December 2, but was still below the high price of $50.35 per troy ounce in 1980. A rise in the price of gold, oil, and mineral commodities in general, was also an important factor in the increased silver price.

Traditional use categories for silver included coin and medal fabrication; industrial applications, including electrical and electronics components; jewelry and silverware; and photography. In 2009, the global use of silver for jewelry and photography continued to decline; however, use for silverware increased. The use of silver in industrial and electronics applications also declined in 2009, owing to the global recession. Silver is widely used in electronic applications, including flat-screen televisions and radio-frequency identification devices (RFIDs), which are used in barcodes, some high-denomination casino chips, passports, and speedpasses. Minting of bullion coins increased in 2009 owing to the surge in investment-related purchases of them, especially in the United States and Europe. The U.S. Mint led the way with a 35% increase to 1,050 t in 2009 from 780 t in 2008, and the global use of silver for coin and medal fabrication increased by 21% in 2009 (Silver Institute, The, 2010, p. 23).

U.S. imports for consumption of refined silver in 2009 decreased by 23% compared with those in 2008. U.S. exports of silver bullion decreased to 167 t in 2009 compared with 413 t exported in 2008. In 2009, Mexico was the leading source of imported refined silver into the United States, followed by Canada, Peru, and Chile. Australia was the leading destination for exported silver, followed by the Republic of Korea, the United Kingdom, and Germany. In 2009, silver was mined in approximately 65 countries; global production was slightly higher than that in 2008, and Peru was the leading producer, followed by Mexico, China, and Australia. The United States was ranked eighth in global silver production in 2009.

Legislation and Government Programs

On September 30, 2009, the amount and value of Deep Storage and Working Stock custodial silver reserves in the U.S. Mint were 498,000 kilograms (kg) of silver with a total market value of $263 million at $16.45 per fine troy ounce and a statutory value of $20.7 million. As custodian, the U.S. Mint is responsible for safeguarding much of the Nation's gold and silver. In accordance with 31 U.S. Code section 5117 (b) and 31 U.S. Code section 5116 (b) (2), a statutory rate of no less than $1.292929292 per fine troy ounce was used to value the custodial silver held by the U.S. Mint (U.S. Mint, 2010). The U.S. Mint's six facilities are in Denver, CO; Fort Knox, KY; Philadelphia, PA; San Francisco, CA; Washington, DC; and West Point, NY.

Production

Domestic mine production data were compiled from 36 operations. Of these operations, 33 responded to the U.S. Geological Survey (USGS) canvass, representing 100% of U.S. mine production listed in table 1. Domestic mine production of silver, which totaled 1,250 t in 2009, was equal to domestic mine production in 2008.

Silver was mostly produced as a byproduct from gold and base-metal ores, although silver was produced as a principal product at Coeur d'Alene Mines Corp.'s (Coeur d'Alene, ID) Rochester Mine, an open pit operation in northwestern Nevada. Coeur announced expanded mining operations that were expected to add 90 metric tons per year of silver production through 2017 (Coeur d'Alene Mines Corp., 2009a). However, silver production decreased by 26 t in 2009 at the Rochester Mine (Coeur d'Alene Mines Corp., 2010). A Federal bankruptcy judge returned ownership of the Sunshine Mine to Sterling Mining Co. (Coeur d'Alene, ID), which had vacated the lease in February (Platts Metals Week, 2009).

In 2009, Hecla Mining Co.'s (Coeur d'Alene, ID) Lucky Friday Mine increased production by 23% owing to improved grade and increased mill throughput. Hecla's combined operations contributed 27 t of growth, and the Greens Creek Mine, ranked ninth in the world in terms of silver production, produced 3% more silver than in 2008. At Teck Resources Ltd. (Vancouver, British Columbia, Canada), byproduct silver production from its lead-zinc operations rose by 10%. At Kennecott Utah Copper Corp.'s (a subsidiary of Rio Tinto plc, London, United Kingdom) Bingham Canyon Mine, silver production rose by 45 t compared with 2008 production, owing to increased mill throughput and focus on production from zones with higher copper, gold, and silver grades (Silver Institute, The, 2010, p. 25). U.S. Silver Corp. (Toronto, Ontario, Canada) conducted an aggressive exploration and development program at its properties in the Silver Valley, ID. Rehabilitation of the Galena shaft began in 2007 and was completed in 2009. This project allowed access to lower levels in the mine and enhanced access to higher grade resources in the upper levels of the mine. Full year 2009 silver production was 75 t compared with full-year 2008 production of 54 t (U.S. Silver Corp., 2010).

At its Troy Mine in northwestern Montana, Revett Minerals Inc. (Spokane Valley, WA) reported that 1.3 million metric tons (Mt) of ore was processed and 35 t of silver was produced in 2009. Silver recovery was lower than that in 2008 owing to lower ore grades and lower recovery rates. Exploration efforts increased and focused on silver occurrences beneath and adjacent to the existing mine. Proven and probable reserves at the Troy Mine were 345 t of silver and would provide a 6-year life-of-mine at the current production rate. Revett continued to advance its Rock Creek project and worked with State and Federal agencies on implementation of wildlife and environmental protection measures (Revett Minerals Inc., 2010).

Apollo Gold Corp.'s (Denver, CO) Montana Tunnels Mine, MT, west of Jefferson City, produced gold, lead, silver, and zinc. In December, Apollo announced that it entered into a replacement letter of intent with Elkhorn Goldfields LLC (Aspen, CO) in which Elkhorn agreed to purchase all outstanding capital stock in Montana Tunnels (Apollo Gold Corp., 2009). Shoshone Silver/Gold Mining Co. (Coeur d'Alene, ID) announced an agreement with Merger Mines Corp. (Coeur d'Alene, ID) to lease 35 patented claims in the Coeur d'Alene District, ID. Shoshone indicated that the exploration potential for the Merger claims is important for Shoshone's future plans (Shoshone Silver/Gold Mining Co., 2009).

Consumption

Domestic consumption of silver decreased by 12% to 5,110 t in 2009 from 5,800 t in 2008, which was comparable to an overall percentage decline in the global consumption of silver during the same period (Silver Institute, The, 2010, p. 52).

Coin and Medal Fabrication.—Approximately 1,050 t of silver was used for coins and medals in the United States in 2009, a 35% increase from the 780 t used in 2008 (Silver Institute, The, 2010, p. 82). In 2009, the leading use of silver in this application was in the fashioning of medals and commemorative pieces that are produced by the U.S. Mint at its San Francisco and West Point locations. The U.S. Mint saw total minting rise by 274 t, and in 2 years, U.S. commemorative coin production had doubled (Silver Institute, The, 2010, p. 23). The use of silver in circulating coins has been mostly phased out.

Industrial Applications.—Approximately 3,000 t of silver was used in the United States in 2009 for industrial applications, a 19% decrease from the 3,700 t used in 2008 (Silver Institute, The, 2010, p. 54). Owing to silver's electrical- and thermal-conducting properties, silver was used in conductors, contacts, fuses, timers, and switches. Other industrial applications of silver included uses in conductive adhesives; in the preparation of thick-film, silver-palladium pastes for use as silkscreen circuit paths in multilayer ceramic capacitors; in the manufacture of membrane switches; in flat-screen televisions with plasma display panels; in silver-backed solar mirrors; as a film in electrically heated automobile windows; in smart cards; and in photovoltaic cells. Silver consumption for photovoltaic cells increased to 870 t in 2009, an increase of 30% compared with 2008 consumption. There are two types of photovoltaic cells—thick- and thin-film—and thick-film applications use more silver and are more widely produced (Silver Institute, The, 2010, p. 62). The high price of fossil fuels and their environmental impact have led to increased research and investments in solar energy technology, and market research suggests that the volume of silver for this application will reach 750 t by 2016 (Commodity Online, 2009). University researchers found that adding nanosilver to the semiconductors in solar panels can boost electric current generation by 12%. Without the silver, 6.2 milliamperes per square centimeter (mA/cm^2) was produced, but with the silver, 7.0 mA/cm^2 was produced. The silver particles allowed the semiconductor to capture a wider range of light wavelengths, which increased the electrical output (Silver Institute, The, 2009).

A small amount of silver was used as a miniature antenna in RFIDs, and the U.S. Department of State has approved the use of passports with embedded RFIDs. These passports are readable at 6 meters, include a digital signature that helps identify if the passport's data have been altered, and the signal is blocked when the passport cover is closed (Corelis, 2008). The U.S. Passport Card, which also uses RFID technology, was introduced in 2008 and allows entry from Bermuda, Canada, the Caribbean, and Mexico. RFID technology is intended to increase efficiency and security at U.S. land and sea border crossings (U.S. Department of State, undated).

In 2009, other industrial applications for silver included its use in batteries, bearings, brazing and soldering, catalysts, disinfectants, mirrors, printed electronics, solar energy production, and water purification. Silver is also used as a coating material for compact disks and digital video disks (Silver Institute, The, 2010, p. 58). Dental amalgam, though in declining use because of its mercury content, may contain 34% to 38% silver (Lawrence, 1995). Owing to silver's antibacterial properties, silver was also used in classroom notebooks, clothing, dental amalgam, laundry machines, shoes, and toothbrushes. Silver embedded in locker room surfaces is being used to reduce staph infections, and silver-based disinfectants have been introduced as a low-cost, environmentally sensitive option for use in care centers and food processing facilities. A nanosilver-based hygiene product, a hand-washing protection kit for H1N1 virus (swine flu), was marketed (Medical News Today, 2009).

Jewelry and Silverware.—In 2009, the U.S. demand for silver for jewelry and silverware was 360 t, a 10% decrease compared with the 400 t used in 2008. World consumption of silver for jewelry and silverware increased slightly, to 6,720 t in 2009, from 6,690 t in 2008 (Silver Institute, The, 2010, p. 68).

Photography.—Silver was one of the essential materials used in the manufacture of films and photographic papers, and Eastman Kodak Co. (Rochester, NY) purchased silver from numerous suppliers. The decline in the use of silver for photography began in 2000 in response to digital camera technology and the decline in the production of color film and paper. Total net sales from Kodak's Film, Photofinishing, and Entertainment Group declined to $2.2 billion in 2009 from $3.0 billion in 2008 (Eastman Kodak Co., 2010, p. 29). Domestic use of silver for photographic use declined by 25% to 680 t in 2009 from 910 t in 2008, which was a 69% decline compared with 2,180 t of silver used in 2000 (Silver Institute, The, 2009, p. 64). The economic downturn resulted in fewer vacations and consequently fewer pictures, and demand for 24-exposure film fell by 29% in 2009. Kodak stopped producing its most well-known film, Kodachrome, in June 2009, owing to declining customer demand in a digital age (Thompson, 2009).

The overall decline in silver use in the photographic industry is also reflected in the film sector itself, in which 747 million rolls of silver-bearing film were sold in 2009, compared with 1.0 billion rolls sold in 2008. Silver-bearing photographic paper consumption declined to 1,050 million square meters in 2009 from 1,160 million square meters in 2008 (Silver Institute, The, 2010, p. 64). Other broad photographic-use categories included commercial photography, dental and industrial x rays, graphic arts, and medical x rays.

Prices

In 2009, the average price of silver was $14.69 per troy ounce, which was slightly below the 2008 average price of $15.02 per troy ounce. On December 2, the price peaked at $19.45 per troy ounce. Owing to the movement of physical silver to the Exchange Traded Fund (ETF) inventory agency in London, domestic exports of silver rose dramatically in 2006. In 2009, the opening of a new silver ETF, ETFS Silver Trust, and rising investment demand boosted the price of silver (Zhou, 2009). Silver inventories in iShares Silver Trust, ETF Securities, and Swiss Zürcher Kantonalbank, totaled approximately 12,370 t at yearend 2009, compared with 8,250 t at yearend 2008 (Silver Institute, The, 2010, p. 100).

Foreign Trade

U.S. imports of refined silver decreased to 3,590 t in 2009 from 4,680 t of refined silver in 2008. Exports of refined silver decreased to 356 t in 2009 from 550 t in 2008. In 2009, principal import sources of silver ores and concentrates, ash and residues, bullion, and dore were Mexico (2,050 t), Canada (747 t), and Peru (261 t) (table 6). Principal export destinations in 2009 were Australia (115 t), the Republic of Korea (56 t), and the United Kingdom (55 t) (table 4). However, U.S. exports of bullion to the United Kingdom continued to decline after a previous high of 1,180 t of bullion shipped in 2006 for the startup ETF inventories in London. Silver bullion imports into India decreased to 1,260 t in 2009 after 5,000 t, an alltime record, was imported in 2008 (Silver Institute, The, 2010, p. 46).

World Review

World mine production of silver was 21,800 t in 2009, a slight increase from the 21,300 t of silver produced in 2008 (table 8). According to the U.S. Geological Survey, in Peru, the world's leading silver-producing country, silver production increased by 4%. Silver production also increased in Mexico (10%) and in China (4%), the world's second and third ranked silver producers, respectively. Regionally, silver production increased in the Commonwealth of Independent States (CIS) by 6% to 2,100 t in 2009 from 1,990 t in 2008; in Asia by 10% to 4,000 t in 2009 from 3,630 t in 2008; and in Latin America by 8% to 7,260 t in 2009 from 6,700 t in 2008. Silver produced from primary silver mines increased by 7% to 6,650 t in 2009 from 6,200 t in 2008; silver produced as a byproduct of gold mining increased by 21%; and silver supplied from base metals was unchanged (Silver Institute, The, 2010, p. 26).

Argentina.—Pan American Silver Corp. (Vancouver) reported an overall increase of 23% in silver production, a new company record, which was owing to smooth startup at its Manantial Espejo Mine, in Santa Cruz. At Manantial Espejo, approximately 110 t of silver was produced at a cash cost of $0.84 per ounce. Beginning in 2010, proven and probable reserves of 1,020 t of silver, improvement of silver recovery, and throughput of 2,000 metric tons per day of ore were expected to make Manantial Espejo Pan American Silver Corp.'s leading silver-producing mine (Pan American Silver Corp., 2010).

Australia.—Silver production decreased by 14% to 1,490 t in 2009 from 1,750 t in 2008. The overall decrease resulted from a first-quarter 28% decline in production at BHP Billiton's Cannington Mine, the world's second leading producer of silver as a principal product. A decline in head grade and high rainfall, which led to flooding at the mine, affected mine output in 2009 (Silver Institute, The, 2010, p. 29).

Bolivia.—Silver production increased by 31% to 1,330 t in 2009 from 1,015 t in 2008 (Silver Institute, The, 2010, p. 26).

In March, Sumitomo Corp. (Tokyo, Japan) took over full ownership of Minera San Cristobal S.A., in the Potosi District of southwestern Bolivia, from its former U.S. partner, Apex Silver Mines Ltd. (Denver, CO), which was reorganized in March under a management agreement as Golden Minerals Co. (Lakewood, CO) (Sumitomo Corp., 2010). San Cristobal reportedly has reserves of 3.2 Mt of zinc, 1.2 Mt of lead, and 12,600 t of silver (Mining Journal, 2009). Production increased by 62 t of silver after a drawn-out ramp-up period (Silver Institute, The, 2010, p. 28). Pan American Silver's mill expansion at San Vincente in the third quarter increased mine output by 57 t (Silver Institute, The, 2010, p. 28). Coeur d'Alene Mines Corp.'s San Bartolome Mine produced 210 t in 2009, its first full year of production, compared with 80 t produced in 2008 (Coeur d'Alene Mines Corp., 2010, p. 24).

China.—Silver production from China increased by 4% to 2,900 t in 2009 from 2,800 t in 2008 (table 8). However, other information indicates that production may have increased by as much as 18% to 2,770 t in 2009 from 2,350 t in 2008 (Silver Institute, The, 2010, p. 26, 28). Silver was produced mainly as a byproduct from copper or lead and zinc mining. Silvercorp Metals Inc. (Vancouver), the leading silver producer in China, has several silver-lead-zinc properties, projects, and mines in China and one property in northern British Columbia Canada. The company generated $54 million in silver sales in 2009 (Silvercorp Metals, Inc., 2010).

Mexico.—In 2009, Mexico was the world's second-ranked producer of silver; however, 2009 silver production increased by 10% from 2008 production levels. In 2008, Fresnillo plc (London, United Kingdom) was spun off from parent company Industrias Peñoles S.A. de C.V., and became the world's leading primary silver producer and an important producer of gold, lead, and zinc from its mines and properties in Mexico. Overall company silver production increased by 5%, to 1,000 t in 2009 from 960 t in 2008, mainly from the company's namesake mine, the Fresnillo Mine in Zacatecas (Fresnillo plc, 2010). Coeur d'Alene Mines' new mine, the Palmarejo Mine, began production of gold and silver in the second quarter of 2009 and produced 85 t of silver in its first partial year of production. The mine has the capacity to produce 220 to 250 t of silver annually (Coeur d'Alene Mines Corp., 2009b; 2010, p. 2).

Peru.—As in 2008, Peru was the world's leading silver producer in 2009. Production increased by 5% to 3,850 t in 2009 from 3,680 t in 2008. The increase was owing to increased production at Hochschild Mining plc's (Lima) Pallancanta Mine, where production increased by 50% after completion of the Selene mill expansion, to 3,000 t per day from 2,000 t per day in the second half of 2008. Pallancanta produced 260 t of silver in 2009 (Hochschild Mining plc, 2010). In 2009, 4 mines in Peru were among the top 15 silver-producing mines in the world (Silver Institute, The, 2010, p. 99). In decreasing order of production, these include Cia. Minas Buenaventura's Uchucchacua Mine, Hochschild Mining plc's Arcata Mine and Pallancata Mine, and Pan American Silver Corp.'s Huaron Mine. However, owing to a decline in ore grade, production decreased by 8% at Buenaventura's Uchucchacua Mine, to 3,280 t in 2009 from 3,550 t in 2008 (Silver Institute, The, 2010, p. 99). Pan American Silver Corp. (Vancouver) reported that its Quirulvilca Mine produced 40 t of silver at a cash cost of $8.64 per ounce in 2009 (Pan American Silver Corp., 2010). Previously, however, the company had considered suspending operations at Quirulvilca owing to the mine's 80-year longevity, increased reliance on zinc production, and declining base-metal prices that made reserves uneconomic (Pan American Silver Corp., 2009).

Outlook

In 2009, world silver consumption was approximately the same as that in 2008 (Silver Institute, The, 2010, p. 79). World silver use in photography continued to fall; however, silver use in photography was expected to level off as silver continues to be used in high-quality paper prints from digital sources. The photovoltaic industry has emerged as a significant industrial-use sector for silver and was expected to be a major segment of silver demand in the future. Silver is known for its antibacterial qualities and was used in bandages, catheters, and other medical applications. Because of these qualities, nanoparticle silver was also used in air cleaners, air conditioners, clothing, and washing machines and dryers. Silver oxide batteries and conductive inks were increasingly being used in the electronics field. A computer mouse, keyboards, paper, pens, and telephones that use antimicrobial silver technology are now being offered. Silver-based biocides were expected to increasingly be used and indicate a new generation of safe and environmentally friendly use of silver for the control of bacterial, viral, and fungal infections, on hard surfaces and in water systems, and as a wood preservative. The use of RFIDs for tracking stock and shipments, including silver-base high-data-capacity tags, readers, and computer systems, was expected to increase. The use of silver in these tags ranges from 6 to 10 milligrams per tag. ETF inventories continued to increase and indicated continued investor interest.

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TABLE 1

SALIENT SILVER STATISTICS[1]

		2005	2006	2007	2008	2009
United States:						
Mine production:						
Quantity	metric tons	1,230	1,160	1,280	1,250	1,250
Value	thousands	$289,000	$431,000	$554,000	$600,000	$588,000
Refinery production:						
Domestic and foreign ores and concentrates	metric tons	2,530	2,210	791	779	796
Scrap (old and new)	do.	981	1,110	1,130 r	1,210 r	1,340
Exports:						
Ore and concentrate	kilograms	3,680	3,150	15,800	130,000	122,000
Refined[2]	do.	338,000	1,670,000	781,000	555,000	356,000
Waste and scrap	metric tons	3,640	2,240	238	2,570	2,480
Imports for consumption:						
Ore and concentrate	kilograms	433	--	381	32	87
Refined	do.	4,530,000	4,830,000	4,980,000	4,680,000	3,590,000
Waste and scrap	do.	3,640,000	2,240,000	3,420,000	5,190,000	4,760,000
Stocks, December 31:						
Industry	metric tons	86	98	70	153	150
Futures exchanges	do.	3,380	3,150	4,130	4,160	4,000
U.S. Department of the Treasury	do.	220	220	220	220	220
Price, average[3]	dollars per troy ounce	7.34	11.61	13.43	15.02 r	14.69
Employment, mine and mill workers[4]		900	900	900	900	850
World, mine production	metric tons	20,800	20,300	21,000 r	21,300	21,800

r Revised. do. Ditto. -- Zero.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Includes refined bullion, dore, and other unwrought silver.

[3] Price data are the annual Handy & Harman quotations published in Platts Metals Week.

[4] Employment data are from the U.S. Department of Labor, Mine Safety and Health Administration.

TABLE 2
MINE PRODUCTION OF SILVER IN THE UNITED STATES, BY STATE[1]

(Kilograms)

State	2007	2008	2009
Nevada	243,000	235,000	203,000
Other[2]	1,040,000	1,020,000	1,040,000
Total	1,280,000	1,250,000	1,250,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes Alaska, Arizona, California, Colorado, Idaho, Missouri, Montana, New Mexico, South Dakota, and Utah.

TABLE 3
LEADING SILVER-PRODUCING MINES IN THE UNITED STATES IN 2009, IN ORDER OF OUTPUT[1]

Rank	Mine	County and State	Operator	Source of silver
1	Red Dog	Northwest Arctic, AK	Teck Alaska Inc.	Zinc-lead ore.
2	Greens Creek	Juneau, AK	Hecla Mining Co.	Zinc-silver ore.
3	Bingham Canyon	Salt Lake, UT	Kennecott Utah Copper Corp.	Copper-molybdenum ore.
4	Lucky Friday	Shoshone, ID	Hecla Mining Co.	Silver ore.
5	Galena	do.	U.S. Silver Corp.	Do.
6	Rochester	Pershing, NV	Coeur d'Alene Mines Corp.	Do.
7	Midas	Elko, NV	Newmont Mining Corp.	Gold ore.
8	Troy	Lincoln, MT	Revett Minerals Inc.	Copper-silver ore.
9	Bagdad	Yavapai, AZ	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum ore.
10	Mission Complex[2]	Pima, AZ	ASARCO LLC	Do.
11	Continental Pit	Silver Bow, MT	Montana Resources	Do.
12	Smoky Valley Common Operation	Nye, NV	Kinross Gold Corp.	Gold ore.
13	Carlin Mines Operations[3]	Elko, Eureka, Humboldt, Lander, NV	Newmont Mining Corp.	Gold-copper ore.
14	Wharf	Lawrence, SD	Wharf Resources Ltd.	Gold ore.
15	Hollister	Elko, NV	Great Basin Gold Ltd.	Do.
16	Denton-Rawhide	Mineral, NV	Kennecott Minerals Co.	Do.
17	Goldstrike[4]	Eureka, NV	Barrick Gold Corp.	Do.
18	Ray	Pinal, AZ	ASARCO LLC	Copper ore.
19	Montana Tunnels	Jefferson, MT	Apollo Gold Corp.	Gold ore.
20	Mineral Park	Mohave, AZ	Mercator Minerals Ltd.	Copper-molybdenum ore.
21	Cresson	Teller, CO	AngloGold Ashanti Ltd.	Gold ore.
22	Hycroft	Humboldt and Pershing, NV	Allied Nevada Gold Corp.	Do.
23	Brushy Creek	Reynolds, MO	Doe Run Resources Corp.	Lead ore.
24	Fletcher	do.	do.	Do.
25	Florida Canyon	Pershing, NV	Jipangu Inc.	Gold ore.

Do., do. Ditto.

[1] The mines on this list accounted for more than 99% of U.S. mine production in 2009.

[2] Includes Eisenhower, Mission, Pima, and San Xavier Mines.

[3] Includes Carlin East, Deep Post, Gold Quarry, Lone Tree, Mule Canyon, Pete, Rain/Emigrant, and Twin Creeks Mines.

[4] Formerly listed as Betze-Post Mine.

TABLE 4
U.S. EXPORTS OF SILVER, BY COUNTRY[1]

Year and country	Silver ores and concentrates		Bullion		Dore		Total	
	Silver content (kilograms)	Value (thousands)	Silver content (kilograms)	Value (thousands)	Silver content (kilograms)	Value (thousands)	Silver content (kilograms)	Value (thousands)
2008	130,000	$50,300	413,000	$203,000	94,800	$36,200	638,000	$289,000
2009:								
Australia	35	21	76,100	42,200	38,800	18,200	115,000	60,500
Bolivia	–	–	–	–	168	82	168	82
Brazil	–	–	827	347	–	–	827	347
Canada	–	–	12,100	6,360	175	44	12,300	6,410
Czech Republic	–	–	126	44	–	–	126	44
Dominican Republic	576	199	–	–	–	–	576	199
Finland	–	–	841	303	162	66	1,000	369
France	18	3	–	–	–	–	18	3
Germany	14,900	8,100	35,900	22,900	7,620	10,300	43,500	33,200
Hong Kong	383	78	4,580	2,750	–	–	4,960	2,830
Ireland	4,180	767	69	33	–	–	4,250	800
Italy	87	18	19	8	22	9	106	26
Japan	–	–	51	25	–	–	51	25
Korea, Republic of	56,500	25,800	–	–	–	–	56,500	25,800
Latvia	1,160	208	–	–	–	–	1,160	208
Lebanon	–	–	111	67	–	–	111	67
Malaysia	–	–	69	39	–	–	69	39
Mexico	7,400	3,900	29,900	15,900	18	7	37,300	19,800
Netherlands	–	–	140	73	–	–	140	73
New Zealand	–	–	403	186	537	189	940	375
Norway	–	–	–	–	2,240	919	2,240	919
Panama	–	–	–	–	1,250	523	1,250	523
Peru	–	–	–	–	605	260	605	260
San Marino	–	–	78	36	–	–	78	36
Singapore	–	–	1,360	672	2,170	851	3,530	1,520
Slovakia	17	3	–	–	–	–	17	3
Spain	–	–	37	17	950	266	987	283
Sweden	34,800	15,700	–	–	–	–	34,800	15,700
Switzerland	–	–	3,720	1,430	21,900	9,430	25,600	10,900
Thailand	972	376	7	4	–	–	979	380
United Kingdom	1,030	199	164	88	53,700	31,500	54,900	31,800
Vietnam	–	–	25	6	–	–	25	6
Other (5 countries)	66	21	14	8	–	–	80	29
Total	122,000	55,400	167,000	93,600	130,000	72,700	404,000	214,000

– Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 5
U.S. EXPORTS OF SILVER, BY COUNTRY[1]

Year and country	Other unwrought silver		Metal powder		Silver nitrate		Semimanufactured forms[2]		Waste and scrap	
	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
2008	47,700	$15,700	890,000	$473,000	34,900	$3,260	720,000	$199,000	2,570,000	$4,290,000
2009:										
Argentina	--	--	--	--	34	9	160	82	--	--
Australia	272	123	23	15	380	52	427	212	--	--
Austria	30	14	115	52	--	--	74	37	--	--
Bahrain	--	--	103	22	--	--	57	28	--	--
Belgium	--	--	4,750	2,390	276	55	42	22	467,000	99,700
Bolivia	560	128	--	--	--	--	46	23	--	--
Brazil	1,080	509	--	--	--	--	42	26	--	--
Canada	17,500	6,290	25,000	5,640	13,900	840	430,000	204,000	116,000	286,000
China	935	487	138,000	73,700	1,820	286	2,090	1,150	15,900	35,400
Costa Rica	233	132	--	--	599	36	44	23	--	--
Cote d'Ivoire	--	--	--	--	--	--	--	--	393	10,000
Czech Republic	--	--	524	135	--	--	--	--	104	39
Denmark	10	4	--	--	--	--	86	43	--	--
Dominican Republic	1,110	471	404	217	95	6	826	418	231	100
Egypt	--	--	--	--	--	--	329	165	--	--
Estonia	--	--	--	--	--	--	140	78	--	--
Finland	--	--	196	53	--	--	83	37	--	--
France	23	5	40,300	20,700	37	3	3,850	2,090	13	66
Germany	761	275	24,300	12,600	262	80	14,100	6,040	845,000	173,000
Guatemala	822	417	--	--	--	--	14	6	10	5
Honduras	166	76	23	10	--	--	--	--	--	--
Hong Kong	7,400	3,620	94,600	52,500	--	--	10,600	5,330	2,330	4,650
India	16,000	4,680	--	--	266	37	4,080	2,050	1,350	5,140
Indonesia	434	227	--	--	--	--	98	48	10	49
Ireland	--	--	270	129	--	--	412	206	--	--
Israel	320	66	543	255	5	7	239	119	--	--
Italy	35	7	199	91	46	4	810	408	817,000	270,000
Japan	17	7	114,000	62,100	--	--	6,770	3,390	4,340	42,700
Jordan	123	35	--	--	--	--	251	125	--	--
Korea, Republic of	86	19	66,900	33,000	32	6	198	104	3,330	9,320
Kuwait	--	--	--	--	42	6	18	7	--	--
Malaysia	--	--	66	24	128	23	1,120	624	50	249
Mexico	3,790	1,560	12,000	5,580	8,280	1,010	36,800	19,100	613	1,980
Netherlands	--	--	12,500	6,800	86	30	86	42	158	460
Netherlands Antilles	61	16	--	--	--	--	--	--	--	--

See footnotes at end of table.

TABLE 5—Continued
U.S. EXPORTS OF SILVER, BY COUNTRY[1]

Year and country	Other unwrought silver		Metal powder		Silver nitrate		Semimanufactured forms[2]		Waste and scrap	
	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
2009—Continued:										
New Zealand	64	$17	–	–	245	$26	–	–	–	–
Nigeria	–	–	–	–	375	45	–	–	–	–
Pakistan	–	–	–	–	–	–	–	–	2,850	$1,670
Paraguay	100	45	–	–	–	–	–	–	–	–
Philippines	100	15	–	–	94	19	370	$191	–	–
Saudi Arabia	–	–	–	–	15	6	665	332	863	7,130
Singapore	407	160	5,890	$2,770	–	–	2,390	1,230	1,200	363
South Africa	10	5	–	–	71	16	–	–	9	92
Spain	61	16	50	24	–	–	–	–	38	188
Sweden	–	–	336	158	79	12	267	$171	32,500	25,200
Switzerland	88	19	851	419	–	–	779	416	104,000	3,160,000
Taiwan	16	3	208,000	112,000	178	12	969	497	721	1,340
Thailand	3,290	626	6,990	3,120	–	–	1,520	811	15	88
Trinidad and Tobago	–	–	9	5	–	–	47	21	–	–
Turkey	–	–	–	–	227	5	6	3	26	131
United Arab Emirates	1,840	796	–	–	–	–	25	12	–	–
United Kingdom	52	26	76,900	39,400	–	–	3,270	1,600	62,500	166,000
Venezuela	28	6	–	–	105	21	127	63	–	–
Vietnam	1,100	267	–	–	100	9	13	6	156	779
Other (5 countries)	64	29	48	33	38	25	213	114	63	737
Total	59,000	21,200	834,000	434,000	27,800	2,690	525,000	251,000	2,480,000	4,300,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Containing 99.5% or more by weight of silver.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF SILVER, BY COUNTRY[1]

	Silver ores and concentrates		Ash and residues		Bullion		Dore		Total	
Year and country	Silver content (kilograms)	Value (thousands)	Silver content (kilograms)	Value (thousands)	Silver content (kilograms)	Value (thousands)	Silver content (kilograms)	Value (thousands)	Silver content (kilograms)	Value (thousands)
2008	32	$31	4,850	$1,280	3,860,000	$1,850,000	574,000	$717,000	4,440,000	$2,570,000
2009:										
Argentina	--	--	--	--	--	--	26,500	21,100	26,500	21,100
Australia	--	--	--	--	40,300	17,900	--	--	40,300	17,900
Belgium	--	--	--	--	688	187	--	--	688	187
Bolivia	--	--	--	--	--	--	131,000	57,800	131,000	57,800
Canada	--	--	--	--	747,000	349,000	--	--	747,000	349,000
Chile	--	--	--	--	125,000	54,000	2,940	1,460	128,000	55,500
Colombia	--	--	--	--	3,510	1,690	814	346	4,330	2,030
Costa Rica	--	--	--	--	--	--	37	15	37	15
Dominican Republic	--	--	--	--	504	65	1,560	567	2,060	632
Germany	--	--	--	--	60	24	--	--	60	24
Guatemala	--	--	--	--	--	--	7,280	11,300	7,280	11,300
Israel	87	9	--	--	--	--	--	--	87	9
Italy	--	--	--	--	83	15	468	162	551	177
Japan	--	--	21	10	--	--	--	--	21	10
Korea, Republic of	--	--	--	--	36,100	17,600	--	--	36,100	17,600
Malaysia	--	--	41	9	--	--	--	--	41	9
Mexico	--	--	--	--	1,630,000	775,000	425,000	284,000	2,050,000	1,060,000
Netherlands Antilles	--	--	--	--	2	3	--	--	2	3
Panama	--	--	--	--	26	13	766	316	792	329
Peru	--	--	--	--	204,000	85,600	57,100	61,900	261,000	147,000
Taiwan	--	--	443	132	15,800	9,630	--	--	16,200	9,760
United Kingdom	--	--	--	--	534	111	--	--	534	111
Total	87	9	505	151	2,800,000	1,310,000	653,000	439,000	3,450,000	1,750,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF SILVER, BY COUNTRY[1]

	Other unwrought silver		Metal powder		Silver nitrate		Semimanufactured forms[2]		Waste and scrap	
Year and country	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
2008	245,000 r	$88,000	61,000	$8,860	10,700	$4,280	418,000	$134,000	5,190,000	$681,000
2009:										
Argentina	--	--	--	--	--	--	--	--	42,200	911
Aruba	--	--	--	--	--	--	--	--	6	43
Australia	--	--	(3)	2	--	--	666	273	697	6,400
Austria	--	--	--	--	--	--	--	--	7	173
Bahamas	--	--	--	--	--	--	--	--	64	433
Barbados	--	--	--	--	--	--	--	--	14	3
Belgium	--	--	--	--	--	--	--	--	677	309
Bolivia	--	--	--	--	--	--	--	--	966	408
Brazil	169	91	--	--	--	--	2,230	572	8,940	1,740
Canada	62,000	22,000	14,400	649	16	2	130,000	64,600	588,000	130,000
Chile	--	--	--	--	--	--	--	--	23,000	1,610
China	--	--	90	19	--	--	--	--	332,000	29,500
Christmas Island	--	--	--	--	--	--	--	--	143	4
Colombia	--	--	--	--	--	--	597	240	138,000	4,720
Costa Rica	--	--	--	--	--	--	--	--	37,300	1,860
Czech Republic	--	--	--	--	--	--	--	--	8	16
Dominican Republic	--	--	76	20	--	--	--	--	5,950	8,450
El Salvador	--	--	--	--	--	--	--	--	8,010	35
Finland	--	--	--	--	--	--	--	--	1	46
France	--	--	816	174	--	--	--	--	51,100	581
Germany	430	16	8,140	1,480	32	12	7,730	1,790	1,160,000	92,000
Guatemala	--	--	--	--	--	--	--	--	31,000	5,470
Honduras	--	--	--	--	--	--	--	--	40,500	586
Hong Kong	--	--	--	--	--	--	--	--	1	56
India	4	3	--	--	420	120	52	34	52,100	7,100
Ireland	--	--	--	--	--	--	--	--	15	12
Israel	--	--	--	--	--	--	--	--	21,600	218
Italy	89	82	(3)	3	--	--	48	32	329	3,650
Jamaica	--	--	--	--	--	--	--	--	(3)	5
Japan	(3)	2	204,000	33,000	31	7	341	123	11,200	8,860
Korea, Republic of	4,000	1,030	6	7	--	--	352	80	122	16
Malaysia	--	--	1,170	118	--	--	--	--	334,000	8,460

See footnotes at end of table.

TABLE 7—Continued
U.S. IMPORTS FOR CONSUMPTION OF SILVER, BY COUNTRY[1]

Year and country	Other unwrought silver		Metal powder		Silver nitrate		Semimanufactured forms[2]		Waste and scrap	
	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
2009—Continued:										
Mauritius	--	--	20	$11	--	--	--	--	--	--
Mexico	60,300	$31,200	15,300	476	--	--	284,000	$89,500	1,300,000	$17,700
Netherlands	5,690	1,030	36	10	--	--	267	81	17,200	139
New Zealand	--	--	--	--	--	--	1	7	--	--
Norway	--	--	--	--	--	--	--	--	1	17
Panama	10	5	--	--	--	--	--	--	570	86
Peru	577	393	--	--	6	$2	49,000	18,100	48,000	645
Philippines	--	--	--	--	--	--	--	--	29,500	2,260
Poland	77	15	--	--	--	--	434	206	--	--
Saudi Arabia	--	--	--	--	--	--	--	--	91	4,000
Singapore	--	--	39	7	--	--	--	--	56,400	2,400
South Africa	--	--	--	--	--	--	--	--	(3)	3
Spain	--	--	--	--	--	--	--	--	2,480	76
St. Lucia	--	--	--	--	--	--	--	--	2	28
Switzerland	18	10	757	129	--	--	--	--	9,750	213
Taiwan	--	--	--	--	--	--	52	10	27,200	17,400
Thailand	6	4	179	31	--	--	9	7	257	2,670
Trinidad and Tobago	--	--	30	4	--	--	--	--	148	9
United Arab Emirates	--	--	--	--	--	--	--	--	366	65
United Kingdom	1,310	263	1,590	234	330	97	414	87	378,000	10,200
Venezuela	--	--	--	--	--	--	--	--	19	535
Total	135,000	56,200	247,000	36,400	835	241	476,000	176,000	4,760,000	372,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Containing 99.5% or more by weight of silver.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8

SILVER: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2005	2006	2007	2008	2009
Algeria	(3)	(3)	(3)	(3)	(3)
Argentina	264	245	256	356 ^{r}	350 ^{e}
Armenia^{e}	4	4	4	4	4
Australia	2,417	1,727	1,879	1,926	1,635
Bolivia	419 ^{r}	472	525	1,114	1,325 ^{p}
Brazil[4]	38	30	36	37 ^{r}	37 ^{p}
Bulgaria^{e}	55	65	55	55	55
Burma	2	1	(3)	--	(3)
Canada	1,124	995	860	728	608
Chile	1,400	1,607	1,936	1,405	1,301
China^{e}	2,500	2,600	2,700	2,800	2,900
Colombia	7	8	10	9 ^{r}	9 ^{e}
Congo (Kinshasa)	54	68	76	34	--
Ecuador	(3)	(3)	(3)	(3)	(3) ^{e}
Ethiopia	1	1	1 ^{r}	1 ^{r}	1 ^{e}
Finland^{e}	49 [5]	50	50	70 ^{r,}[5]	70
France^{e}	1	1	1	1	1
Ghana	4	3	3	3	3 ^{e}
Greece	79 ^{e}	25	26	28	30 ^{e}
Guatemala	7	50	88	100	128
Honduras	54	55	50 ^{e}	12	15 ^{e}
India	32	31	82	96	95
Indonesia	321	261	269	226 ^{r}	215
Iran^{e}	25	25	26	25	25
Ireland^{e}	6 [5]	4 [5]	4	4	4
Italy^{e,}[6]	(3)	(3)	(3)	(3)	(3)
Japan	54	11	5	2	2
Kazakhstan	832	806 ^{r}	723 ^{r}	646 ^{r}	678
Korea, North^{e}	20	20	20	20	20
Korea, Republic of	4	2	1	1	2 ^{e}
Malaysia	(3)	(3)	(3)	(3) ^{e}	(3) ^{e}
Mexico	2,894	2,970	3,135	3,236	3,554
Mongolia^{e}	28	28	10 ^{r}	10 ^{r}	10
Morocco^{e}	196	195 [5]	195	190	195
Namibia^{e}	30 [5]	31 [5]	30	30	30
New Zealand	43	27	11	18 ^{r}	14
Nicaragua^{e}	3 [5]	3 [5]	3	3	3
Oman	(3) ^{e}	(3) ^{r}	(3) ^{r}	(3) ^{r}	(3)
Papua New Guinea	51	51	51	51	52 ^{e}
Peru	3,206	3,471	3,494	3,686	3,854
Philippines	19	24	28	14 ^{r}	34

See footnotes at end of table.

TABLE 8—Continued

SILVER: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2005	2006	2007	2008	2009
Poland	1,263 r	1,266 r	1,199 r	1,161 r	1,206
Portugal	24	20	24	24	--
Romania e	15	18	18	18	18
Russia e	1,350 [5]	1,250	1,200	1,300	1,400
Saudi Arabia	14	9 e	9	8	10 e
Serbia e	3 [5, 7]	2	4 [5]	4	4
South Africa	88	87	70	75	78
Spain	3 r	2 r	3 r	3 r	4 p, e
Sudan e	3	2 [5]	2 [5]	2	2
Sweden	310	268	270	265	265 e
Tajikistan e	5	5	5	5	5
Tanzania	13	15	12	11 r	12 e
Tunisia e	1 [5]	--	--	--	--
Turkey	138	167	198	180	180 e
United States	1,230	1,160	1,280	1,250	1,250
Uzbekistan e	83	83	83	83	85
Zimbabwe	3	1	1	1 e	1 e
Total	20,800	20,300	21,000 r	21,300	21,800

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e Estimated. p Preliminary. r Revised. -- Zero.

[1] World totals, U.S. data, and estimated data have been rounded to no more than three significant digits; may not add to totals shown.

[2] Recoverable content of ores and concentrates produced unless otherwise specified. Table includes data available through August 19, 2010.

[3] Less than ½ unit.

[4] Reported figure.

[5] Includes the following quantities, in kilograms, indentified as secondary silver: 2005—43,000 (revised); 2006—39,000 (revised); 2007-08—32,000 (revised); and 2009—32,000.

[6] Includes production from imported ores.

[7] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

SLAG—IRON AND STEEL

By Hendrik G. van Oss

Sales in 2009 of iron and steel slag in the United States taled about 12.5 million metric tons (Mt), down by almost 4% from total sales in 2008 (table 1). The overall value of slag les decreased by 29% to about $235 million.

Iron and steel slags form through the addition of slagging gents and fluxes (chiefly limestone or dolomite and silica and) to blast furnaces and steel furnaces to strip impurities om iron ore, steel scrap, and other ferrous feeds. The slag s a silicate melt that floats on top of the molten crude iron r steel and is tapped from the furnace separately from the quid metal. After cooling by various means to solid form, e slag is processed and may then be sold and (or) returned to e furnace. Most forms of processed slag have very low unit alues compared with those of iron and steel products and, or this reason, iron and steel companies generally contract vith outside slag-processing companies to cool the slag and to emove it. Although the financial arrangements vary, typically he processing company receives the slag for free, crushes it to arious marketable sizes, uses screens and magnetic separators o recover entrained metal from the slag (metal to be returned to he furnace for a low charge), sells the slag on the open market, nd pays a small percentage of the net slag sales revenues or rofits to the iron or steel company. Slag may be returned to the urnaces for use as flux and as a supplemental source of iron; his return of slag is not always included in the tonnages of slag eported as sold.

A list of slag processors, processing sites, and the iron and teel companies serviced is provided in table 4. Apparent uplication at some sites is because processing contracts may ave been transferred to other companies during the year, and ntegrated iron and steel plants may have processing and (or) arketing contracts with different companies for different slag ypes produced at the plant. In some cases, the slag is cooled by ne company but is then further processed and (or) marketed by nother company or at another site.

Legislation and Government Programs

Consumption of slag in the construction sector is influenced by Federal and State programs that affect construction spending levels, encourage the use of "alternative" materials, and that may affect the availability of competing "alternative" or natural materials. Slags are promoted as "sustainable" raw materials mainly on the basis that slags substitute directly or indirectly for virgin raw materials (for example, for natural stone aggregates in concrete and for natural raw materials in cement manufacture), or, in the specific case of ground granulated blast furnace slag (GGBFS), can partially substitute for clinker in finished cement or for portland cement in concrete. With respect to clinker manufacture, substitution of slags for natural raw materials can reduce the unit consumption of fuel and limestone in the kiln, which then reduces the overall and unit emissions of certain pollutants, most notably carbon dioxide. Use of granulated blast furnace slag [GGBFS, or unground (GBFS)] in the finish mill allows more finished cement to be made from the same amount of clinker. In 2009, the ASTM C–150 standard for portland cement was revised to allow for the inclusion of up to 5% (by weight) of inorganic process additions; this was expected to lead to more widespread use of GBFS as a grinding aid in cement manufacture.

In May, the U.S. Environmental Protection Agency (EPA) proposed, within a set of National emissions standards for hazardous air pollutants (NESHAP) for the U.S. cement industry, new, very low, limits on emissions of certain pollutants, most notably of mercury (U.S. Environmental Protection Agency, 2009). The NESHAP had the potential, through the closure of plants unable to meet the new limits, to reduce the supply of domestically produced cement on the U.S. market and thus to increase demand for alternative or supplementary cementitious materials (SCM) such as GGBFS and fly ash. The proposed rule likely would make fly ash (typically relatively high in mercury) less attractive as an alternative raw material for clinker manufacture and thus might increase demand for slag for this purpose. The EPA was also evaluating the reclassification of coal combustion byproducts, including fly ash, as hazardous waste for landfill disposal purposes (but not for beneficial use purposes). If even a limited designation as hazardous waste were to stigmatize fly ash, construction market demand for this material might fall significantly. It is unclear if the supply of GGBFS and other SCM would be adequate to fill the fly ash void, and this availability issue might work against efforts to promote increased use of these materials.

Production

Data on actual annual production of slag are generally unavailable because the amount of slag tapped is not routinely measured; also, not all of the slag formed is tapped during a heat. However, U.S. and world production of ferrous slags can be broadly estimated based on typical slag to metal production ratios, which in turn are related to the chemistry of the ferrous feeds to the furnaces. For typical iron ore grades (60% to 66% iron), a blast furnace normally will produce about 0.25 to 0.30 metric tons (t) of slag per metric ton of crude or pig iron produced. For ores of lower than average grade, the slag output will be higher, in some cases as much as 1.0 to 1.2 t of slag per ton of crude iron. Steel furnaces typically produce about 0.2 t of slag per ton of crude steel, but up to 50% of this slag is entrained metal, most of which is generally recovered during slag processing and returned to the furnace. The amount of marketable steel slag remaining after entrained metal removal is thus usually equivalent to about 10% to 15% of the crude steel output. Using these ratios and data for U.S. and world iron and steel production from the American Iron and Steel Institute (2009, p. 121–126), U.S. blast furnace slag production in 2009 was estimated to be in the range of about 5 to 6 Mt, and world output, 230 to 270 Mt. Similarly, U.S. output of steel slag (after metal removal) in 2009 was estimated to be 6 to 9 Mt, and world output, 120 to 180 Mt. Apparent production of slag may differ from the sales of slag (table 1) because of a combination of undocumented returns of slag to the furnaces, stockpiling of slag by the processors, and sales from stockpiles.

The market uses for ferrous slag are determined mainly by how the slag is cooled. Marketed blast furnace slags are of three main types—air-cooled, granulated, and pelletized (or expanded). Air-cooled blast furnace slag is formed by allowing the molten slag to cool relatively slowly under ambient conditions; final cooling can be accelerated with a water spray. Although it can have a vesicular texture with closed pores, the cooled slag is hard and dense and is especially suitable for use as construction aggregates. Formation of GBFS is by quenching molten slag in water to form sand-sized particles of glass. The disordered structure of this glass gives the material inherent moderate hydraulic cementitious properties when the slag is very finely ground, and the cementitious properties become strong if the GGBFS accesses free lime during hydration. Pelletized or expanded slag is cooled through a water jet, which leads to rapid steam generation and the development of innumerable vesicles within the slag. The vesicular texture reduces the overall density of the slag and allows for good mechanical binding with hydraulic cement paste. This slag type is most commonly used as a lightweight aggregate, but if very finely ground, it can have cementitious properties similar to those of GGBFS. Blast furnace slag (generally air-cooled) also can be made into mineral wool. Slag for this purpose is remelted and then poured through an air stream or jet of steam or other gas to produce a spray of molten droplets; alternatively, the droplets can be formed by passing the melt through a perforated or fast spinning disc. The droplets elongate into long fibers that are collected and layered, and this material is suitable for use as thermal insulation.

Steel furnace slag is cooled similarly to air-cooled blast furnace slag, has similar properties to it, and is used for some of the same purposes. Steel slags containing large amounts of dicalcium silicate are prone to expansion and commonly are cured in piles for several months to allow for the expansion and for leaching out of lime.

Consumption

Data in this report are based on an annual U.S. Geological Survey (USGS) canvass of slag processors and importers and relate to sales of processed slag, not the amount of slag produced or processed during the year. Processed slag is sold from stockpiles and although most of the material is a byproduct of current or recent iron and steel output or is of imported material, some slag sales are of material mined from old slag piles (slag banks) produced by iron and steel plants now closed. In 2009, canvasses were sent to 22 companies, covering 137 processing and (or) importation sites, and at least partial data (some as consolidated responses) were received for 130 sites; the reported data accounted for slightly more than 96% of the total iron and steel slag total in table 1. For 2008, canvasses were sent to 28 companies, covering 135 processing sites, and at least partial data were received for 122 of the sites, accounting for slightly more than 90% of the gross tonnage listed for the year. Owing to a wide range in the level of data detail reported to the USGS and the need to estimate activities of survey nonrespondents, the data in table 1 have been heavily rounded. For both years, data on pelletized blast furnace slag have been withheld to avoid disclosing company proprietary data, but the quantities sold were very small. Sales data for granulated slag in both years exclude material sold by importers who as yet do not take part in the USGS canvass.

Sales data exclude much of the ferrous slag returned to the furnaces and the weight of free metal recovered from the slag. For both years, air-cooled blast furnace slag and steel furnace slag together accounted for 82% of sales tonnages; however, the tonnages for both slag types fell by about one-third in 2009 (table 1). Although both slag types are used in the general construction sector, their market areas tend to be somewhat restricted geographically relative to natural construction materials, and sales are commonly based upon long-term contracts; both factors have tended to protect slag sales in some years (such as in 2008) relative to competing materials. In contrast to relative sales volumes in 2008, the percentage decline in sales of slag in 2009 was larger than that of some other, more widely consumed, construction materials canvassed by the USGS [cement (as a proxy for concrete overall), down by 26%; crushed stone, down by 20%; and sand and gravel, down by 25%]. All of these declines reflected low construction spending levels; those for slag, however, appear to have also reflected reduced supplies resulting from wholesale closure or long-term idling of blast furnaces and steel furnaces during the year and an increasing trend for steel companies to take back more of the slag for use as a flux and (or) ferrous feedstock.

Air-cooled blast furnace and steel furnace slags are used primarily for a variety of aggregate applications (table 3). Because of potential expansion problems, steel slag finds little use in applications requiring maintenance of a fixed volume (for example, concrete). Both slag types also are used as a raw material for cement (clinker) manufacture (the slag contributes several major oxides), but steel slag has proven to be especially suitable for this use. Differences evident among the usage breakout percentages for these two slag types in table 3 are difficult to evaluate because the data incorporate estimates, and much of the plant-level data reported in recent years have revealed only the dominant use(s) for the slag and thus the less common uses are likely understated.

Despite the significantly lower tonnages sold in 2009, selling prices for air-cooled and steel furnace slags appear to have fallen only modestly (table 2); however, the changes shown may not be statistically significant owing to the incorporation of estimates and a lack of response detail on many canvasses. Because of generally low unit sales values, slag sold for aggregate generally cannot be economically transported over long distances, particularly overland. Thus, the major factors affecting the sales volumes and prices of these two slag types are dominated by local competition from natural aggregates, the overall level of construction activity (particularly that for roads), and the existence of long-term supply contracts. Air-cooled and steel furnace slags sold for uses other than aggregates can command higher prices than slags sold as aggregates. Pelletized slag (not revealed in tables 1–3) can sell for prices well above those for air-cooled slag.

Sales of GBFS slag decreased by 31% to 2.2 Mt in 2009, and while this was only 18% of total slag sales tonnages, GBFS accounted for 73% of the value of total slag sales and 84% of the value of blast furnace slag sales, owing to the high unit value of the granulated material (tables 1, 2). Actual sales of GBFS in some years have been higher than those shown in table 1 because of some imports being missed by the USGS canvass; however, it is unclear if this was the case in 2009. About 92% of total reported GBFS sales represented GGBFS and the rest was unground material; the GGBFS fraction in 2008 was about 86%. The high unit sales value of GBFS reflects the dominant use of GGBFS as a partial substitute for portland cement in blended cements and in concrete. In concrete containing a proportion of GGBFS, hydration of portland cement releases the lime needed to fully activate the slag. Concretes incorporating GGBFS generally develop strength more slowly than concretes that contain only portland cement but can have similar or even superior long-term strength, release less heat during hydration, have reduced permeability, and generally exhibit improved resistance to chemical attack. Despite its relatively high unit price, GGBFS still sells at a 20% to 25% discount to portland cement. Unground GBFS was sold primarily to cement plants, to dedicated slag-grinding plants for conversion to GGBFS, or to cement plants to be used as a grinding aid (for portland cement) in their finish mills. Overall sales for cementitious uses of GBFS and GGBFS totaled 2.1 Mt in 2009, down by 25%. A small fraction of the unground GBFS on the market has been sourced from old slag piles and lacks cementitious character as a result of weathering; this material still has use in concrete (as a fine grain aggregate), but sells for much lower prices than those indicated for the cementitious material in table 2.

The USGS slag survey does not distinguish between GBFS sold directly to cement companies and that sold directly to concrete companies, but data from recent USGS cement surveys indicate that cement producers consume only about 15% of the total granulated slag sold. Sales in the United States of GGBFS under the designation "slag cement" are promoted by the Slag Cement Association (SCA), whose members accounted for much of the country's GGBFS output. The SCA reported sales by its members of 2.1 Mt of GGBFS in 2009, a decline of 31% (Slag Cement Association, unpub. data, November 2010).

Foreign Trade

Slag imports are dominated by GBFS, but the data within the appropriate tariff code commonly contain entries that, because of unreasonably high or low unit dollar values, are likely either slags from other metallurgical industries or are not slag at all (such as silica fume, cenospheres from fly ash, other industrial residues). Thus, while the data from the U.S. Census Bureau list imports of granulated slag totaling about 1.28 Mt in 2009, down only by about 3% from levels in 2008, the true GBFS tonnages within the data for both years are unclear. Taken without adjustment, the leading import sources of GBFS tonnages in 2009 were Japan (50%), Canada (38%), South Africa (7%), and Italy (3%). Comparison of the Census Bureau import data for slag with data from the United Business Media Ltd.'s Port Import Export Reporting Service (PIERS) has generally revealed higher totals for PIERS in recent years, suggesting that the Census Bureau data were incomplete. In 2009, however, the PIERS total was just 1.12 Mt. Much of the difference in 2009 stems from an apparent absence of imports from South Africa in the PIERS data; the very high unit value for this material in the Census Bureau data suggests that the South African material may not have been slag at all. Both data sets showed abnormally low unit values for 0.1 Mt to 0.2 Mt of the material from Japan; informal information about this material indicates that it was slag from another metallurgical industry and not GBFS.

Outlook

Construction spending levels, especially for public sector projects, will continue to be the key determinant of sales of ferrous slags for use as aggregates. Demand for slag is expected to benefit from Government programs to promote the use of recovered mineral components in public sector construction projects but may not be able to capture a large share of this market because of limited slag availability. The declining number of operating blast furnaces in the United States makes the future supply of air-cooled blast furnace slag highly vulnerable to even temporary closure of integrated iron and steel complexes, such as were experienced in 2009. Steel slag supplied from basic oxygen furnaces is also vulnerable to closures, although overall slag availability from electric arc furnaces is more assured. A growing constraint on steel slag availability is a recent tendency for steel plants to retain more slag for return to the furnaces at times of high prices for iron ore and scrap. In terms of actual sales volumes, however, the effects of these increased returns to the furnace are hard to quantify because of the tendency of slag processors to stockpile slag so as to be able to bid on large projects. Slags are useful alternative raw materials for clinker production, and such use can reduce a cement plant's fuel consumption and overall emissions of carbon dioxide. Availability of sufficient slag near the cement plant will continue to be a major determinant of demand for this purpose, as will the slag's chemical suitability.

Growing acceptance of GGBFS as a component of finished cement and concrete would seem to assure a steady demand for this slag type, contingent on overall construction levels. The supply of GBFS from domestic blast furnaces is severely constrained by the fact that granulation cooling is currently installed at only four blast furnaces in the United States. Installation of granulators at other blast furnaces is possible but expensive and would hinge on the perception of the specific furnace's future viability. Further, some blast furnaces produce a slag that, while suitable for aggregate use, is chemically unsuitable for use as GBFS. It is likely that significant future growth in the domestic market for GGBFS will hinge on increased availability of imported material.

Current proposed changes in environmental rules governing the manufacture of portland cement and the characterization of fly ash have the potential of increasing the demand for slag as an alternative raw material for clinker manufacture and as an SCM. This assumes that supplies of portland cement and SCM in general do not become so constrained as to cause delays to, or cancellation of, construction projects, or make impractical the widespread use of SCM in concrete.

References Cited

American Iron and Steel Institute, 2009, Annual statistical report: Washington, DC, American Iron and Steel Institute, 126 p.

U.S. Environmental Protection Agency, 2009, National emissions standards for hazardous air pollutants from the portland cement manufacturing industry; proposed rule: Federal Register, 40 CFR Parts 60 and 63, v. 70, no. 86, May 6, p. 21136–21192.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publication

Iron and Steel Slag. Ch. in Mineral Commodity Summaries, annual.

Other

National Slag Association.
Portland Cement Association.
Slag Cement Association.

TABLE 1

IRON AND STEEL SLAG SOLD OR USED IN THE UNITED STATES

(Million metric tons and million dollars)

	2008					2009				
	Blast furnace slag[1]			Steel	Total iron	Blast furnace slag[1]			Steel	Total iron
	Air-cooled	Granulated	Total[2]	furnace slag	and steel slag	Air-cooled	Granulated	Total[2]	furnace slag	and steel slag
Quantity	6.9	3.2	10.1	8.7	18.8	4.6	2.2	6.8	5.7	12.5
Value[e]	53	236	288	43	332	33	172	205	30	235

[e] Estimated.

[1] Excludes expanded (pelletized) slag to protect company proprietary data. The quantities are very small (about 0.1 unit or less).

[2] Data may not add to totals because of independent rounding.

TABLE 2

SELLING PRICES FOR IRON AND STEEL SLAG IN THE UNITED STATES[1]

(Dollars per metric ton)

	2008		2009	
Slag type	Range	Average	Range	Average
Blast furnace slag:				
Air-cooled	1.84 - 19.84	7.64	3.31 - 19.84	7.35
Granulated[2]	24.65 - 100.50	82.64	20.00 - 100.00	81.37
Steel furnace slag	0.20 - 15.39	5.02	0.19 - 14.66	5.28

[1] Data contain a large component of estimates and some respondents provide values only on their total sales of a slag type, not value by type of use. Thus the value ranges shown are likely too restrictive.

[2] Values are for material reported for use as a cementitious additive in cement or concrete manufacture. Material at or near the low end of the range was sold in unground form. Sales other than for cementitious use were generally at unit values below the ranges shown.

TABLE 3
SALES OF FERROUS SLAGS IN THE UNITED STATES, BY USE[1]

(Percentage of total tons sold)

	2008			2009		
	Blast furnace slag[2]		Steel	Blast furnace slag[2]		Steel
Use	Air-cooled	Granulated	slag	Air-cooled	Granulated	slag
Ready-mixed concrete	18.1	--	--	16.9	--	--
Concrete products	3.2	--	--	3.7	--	--
Asphaltic concrete	13.4	--	10.9	16.8	--	8.2
Road bases & surfaces	40.2	9.4	60.3	39.1	4.2	59.9
Fill	12.7	--	10.8	9.3	--	12.7
Cementitious material	--	87.1	--	--	94.3	--
Clinker raw material	2.8	2.5	5.0	0.9	1.0	2.2
Miscellaneous[3]	8.2	--	0.5	11.9	0.5	0.5
Other or unspecified	1.3	1.0	12.7	1.4	--	16.5

-- Zero.

[1] A number of respondents provide breakouts that represent only the dominant use(s) of their slag; accordingly, the minor use categories are likely underreported. The data also incorporate some estimates and thus should be viewed as good to no more than two significant figures.

[2] Excludes expanded or pelletized slag; this material is generally sold as a lightweight aggregate.

[3] Reported as used for mineral wool, railroad ballast, roofing, sewage treatment, or soil conditioner.

TABLE 4

PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2009

			Slag and furnace types[1]					
			Blast furnace slag			Steel furnace slag		
Slag Processing Company	Plant Location	Steel Company Serviced[2, 3]	AC	GG	Exp	BOF	OHF	EAF
Alexander Mill Services Inc.	Hollsopple, PA	North American Höganäs, Inc.						X
Barfield Enterprises, Inc.	LaPlace, LA	ArcelorMittal USA						X
Beaver Valley Slag	Aliquippa, PA	Old slag pile site	X			X	X	
Beelman Truck Co.	Granite City, IL[4]	United States Steel Corp.	X					
Beemsterboer Slag Corp.	East Chicago, IN	ArcelorMittal USA (East side)	X					
Do.	Gary, IN	United States Steel Corp.	X					
Blackheart Slag Co.	Muscatine (Montpelier), IA	SSAB North America						X
Edward C. Levy Co.	Decatur (Trinity), AL	Nucor Corp.						X
Do.	Butler, IN	Steel Dynamics, Inc.						X
Do.	Columbia City, IN	do.						X
Do.	Crawfordsville, IN	Nucor Corp.						X
Do.	East Chicago (Indiana Harbor), IN	ArcelorMittal USA (West side)	X					
Do.	Detroit, MI	Severstal North America, Inc.	X			X		
Do.	do.	United States Steel Corp.	X			X		
Do.	Columbus, MS	Severstal North America, Inc.						X
Do.	Delta, OH	North Star BlueScope Steel LLC						X
Do.	Canton, OH	The Timken Co.						X
Do.	Huger, SC	Nucor Corp.						X
Do.	Seattle, WA	do.						X
Essroc Corp.	Middlebranch, OH	Miscellaneous domestic & foreign		X				
Fritz Enterprises, Inc.	Birmingham (Fairfield), AL[5]	United States Steel Corp.	X	X		X		
Do.	Sparrows Point, MD	Severstal North America, Inc.	X					
Gerdau Ameristeel Corp.	Jacksonville, FL	Gerdau Ameristeel Corp.						X
Do.	Charlotte, NC	do.						X
Holcim (US) Inc.	Birmingham (Fairfield), AL[5]	United States Steel Corp.		X				
Do.	Camden, NJ	Foreign		X				
Do.	Gary, IN	United States Steel Corp.		X				
Lafarge North America Inc.	South Chicago, IL	ArcelorMittal USA		X				
Do.	East Chicago (Indiana Harbor), IN[6]	do.		X	X			
Do.	Sparrows Point, MD	Severstal North America, Inc.	X	X				
Do.	Cleveland (Cuyahoga Co), OH[4]	ArcelorMittal USA	X					
Do.	Lordstown, OH	Old slag pile site		X				
Do.	McDonald, OH	do.	X					
Do.	Salt Springs (Youngstown), OH	do.	X					
Do.	Warren, OH	Severstal North America, Inc.	X					
Do.	West Mifflin (Duquesne), PA	United States Steel Corp. (ET Works)	X					

See footnotes at end of table.

TABLE 4—Continued

PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2009

Slag Processing Company	Plant Location	Steel Company Serviced[2, 3]	Slag and furnace types[1]					
			Blast furnace slag			Steel furnace slag		
			AC	GG	Exp	BOF	OHF	EAF
Lafarge North America Inc.—Continued	Seattle, WA	Foreign		X				
Lehigh Cement Co.	Evansville, PA	do.		X				
Lehigh/Hanson Slag Cement, Inc.	Cape Canaveral, FL	do.		X				
Lehigh Northeast Cement Co.	Cementon, NY	do.		X				
The Levy Co., Inc.	Burns Harbor, IN	ArcelorMittal USA	X			X		
Mountain Enterprises, Inc.	Ashland, KY[4]	AK Steel Corp.	X					
MultiServ	Birmingham, AL	SMI/CMI Steel Group						X
Do.	Blytheville, AR	Nucor Corp.						X
Do.	Blytheville (Armorel), AR	Nucor-Yamato Steel Co.						X
Do.	Pueblo, CO	Evraz Inc. NA						X
Do.	Wilton (Muscatine), IA	SSAB North America						X
Do.	Indiana Harbor, East Chicago, IN[7]	ArcelorMittal USA				X		
Do.	Pittsboro, IN	Steel Dynamics, Inc.						X
Do.	Ghent, KY	Gallatin Steel Co.						X
Do.	do.	North American Stainless						X
Do.	Ahoskie (Cofield), NC	Nucor Corp.						X
Do.	Canton, OH[8]	Republic Engineered Products, Inc.						X
Do.	Mansfield, OH	AK Steel Corp.				X		
Do.	Warren, OH	Severstal North America, Inc.				X		
Do.	Brackenridge, PA	Allegheny Ludlum Corp.						X
Do.	Butler, PA	AK Steel Corp.						X
Do.	Coatsville, PA	ArcelorMittal USA						X
Do.	Koppel, PA	TMK IPSCO						X
Do.	Latrobe, PA	Allegheny Ludlum Corp.						X
Do.	Natrona Heights, PA	do.						X
Do.	Steelton, PA	ArcelorMittal USA						X
Do.	Midlothian, TX	Gerdau Ameristeel Corp.						X
Do.	Geneva (Provo), UT	Old slag pile site	X			X		
Phoenix Services LLC	Riverdale, IL	ArcelorMittal USA				X		
Do.	Indiana Harbor, East Chicago, IN[7]	do.				X		
Do.	Wilton, IA	Gerdau Ameristeel Corp.						X
Do.	Sparrows Point, MD	Severstal North America, Inc.				X		
Do.	Latrobe, PA	Latrobe Specialty Steel Co.						X
Do.	Vinton (El Paso), TX	ArcelorMittal USA						X
Do.	Roanoke, VA	Steel Dynamics, Inc.						X
Do.	Weirton, WV	Old slag pile site					X	

See footnotes at end of table.

TABLE 4—Continued
PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2009

Slag Processing Company	Plant Location	Steel Company Serviced[2, 3]	Slag and furnace types[1]: Blast furnace slag: AC	GG	Exp	Steel furnace slag: BOF	OHF	EAF
Recmix of PA, Inc.	Ghent, KY	North American Stainless						X
Do.	Sarver (Brackenridge), PA	Allegheny Ludlum Corp.						X
Rinker Materials Corp.	Miami, FL	Foreign		X				
St. Marys Cement Inc.	Detroit, MI	do.		X				
Do.	Milwaukee, WI	Domestic and foreign		X				
Stein, Inc.	Alton, IL	Alton Steel Inc.						X
Do.	Granite City, IL[4]	United States Steel Corp.	X			X		
Do.	Sterling, IL	Sterling Steel Co., LLC						X
Do.	Ashland, KY[4]	AK Steel Corp.	X			X		
Do.	Canton, OH[8]	Republic Engineered Products, Inc.						X
Do.	Cleveland, OH[4]	ArcelorMittal USA	X			X		
Do.	Loraine, OH	Republic Engineered Products, Inc.	X			X		
Do.	Georgetown, SC	Georgetown Steel Corp.						X
Tube City IMS, LLC	Axis, AL	SSAB North America						X
Do.	Birmingham, AL	Nucor Corp.						X
Do.	Tuscaloosa, AL	do.						X
Do.	Fort Smith, AR	GerdauMACSTEEL						X
Do.	Rancho Cucamonga, CA	TAMCO Steel						X
Do.	Claymont, DE	Evraz Inc. NA						X
Do.	Cartersville, GA	Gerdau Ameristeel Corp.						X
Do.	Kankakee, IL	Nucor Corp.						X
Do.	Peoria, IL	Keystone Steel & Wire Co.						X
Do.	Gary, IN	United States Steel Corp.				X		
Do.	Portage, IN	NLMK Indiana (Beta Steel Corp).						X
Do.	Ashland, KY	Kentucky Electric Steel LLC						X
Do.	Jackson, MI	GerdauMACSTEEL						X
Do.	Monroe, MI	do.						X
Do.	St. Paul, MN	Gerdau Ameristeel Corp.						X
Do.	Jackson, MS	Nucor Corp.						X
Do.	Norfolk, NE	do.						X
Do.	Perth Amboy, NJ	Gerdau Ameristeel Corp.						X
Do.	Sayreville, NJ	do.						X
Do.	Auburn, NY	Nucor Corp.						X
Do.	Marion, OH	do.						X
Do.	McMinnville, OR	Cascade Steel Rolling Mills, Inc.						X
Do.	Middletown, OH	AK Steel Corp.	X			X		

See footnotes at end of table.

TABLE 4—Continued

PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2009

			Slag and furnace types[1]					
			Blast furnace slag			Steel furnace slag		
Slag Processing Company	Plant Location	Steel Company Serviced[2, 3]	AC	GG	Exp	BOF	OHF	EAF
Tube City IMS, LLC —Continued:	Mingo Junction, OH	Severstal North America, Inc.	X			X		X
Do.	Youngstown, OH	V&M Star						X
Do.	Sand Springs, OK	Gerdau Ameristeel Corp.						X
Do.	Braddock, PA	United States Steel Corp.				X		
Do.	Bridgeville, PA	Universal Stainless & Alloy Products, Inc.						X
Do.	Midland, PA	Allegheny Ludlum Corp.						X
Do.	New Castle, PA	Ellwood Quality Steels Co.						X
Do.	Park Hill (Johnstown), PA	Old slag pile site	X				X	
Do.	Pricedale, PA	do.				X		
Do.	Reading, PA	Carpenter Technology Corp.						X
Do.	Cayce, SC	SMI/CMC Steel Group						X
Do.	Darlington, SC	Nucor Corp.						X
Do.	Jackson, TN	Gerdau Ameristeel Corp.						X
Do.	Knoxville, TN	do.						X
Do.	Beaumont, TX	do.						X
Do.	Jewett, TX	Nucor Corp.						X
Do.	Lone Star, TX	Lone Star Steel Co.						X
Do.	Longview, TX	LeTourneau Technologies Steel Products						X
Do.	Seguin, TX	SMI/CMC Steel Group						X
Do.	Plymouth, UT	Nucor Corp.						X
Do.	Petersburg, VA	Gerdau Ameristeel Corp.						X
Do.	Saukville, WI	Charter Steel						X
Uniserve LLC	Newport, AR	Arkansas Steel Associates, LLC						X
Do.	Gallatin, TN	Hoeganaes Corp.						X
Vulcan Materials Co.	Tampa, FL	Foreign		X				

Do., do. ditto.

[1] Blast furnace slag type abbreviations: AC = air-cooled; GG = granulated; Exp = expanded. Steel furnace slag types: BOF = basic oxygen furnace; OHF = open hearth furnace; EAF = electric arc furnace.

[2] "Foreign" refers to the fact that the facility imports unground granulated blast furnace slag and grinds it onsite to make ground granulated blast furnace slag—commonly now referred to as "slag cement." "Domestic" implies grinding slag sourced from the domestic market, not a service contract.

[3] Currently operating iron and (or) steel company. Company is not shown for old slag pile sites.

[4] For the air-cooled slag, Stein was responsible for the cooling but the processing and marketing were handled by Beelman Trucking (Granite City, IL), Lafarge Corp. (Cleveland, OH), and Mountain Enterprises, Inc. (Ashland, KY), respectively.

[5] For granulated slag, Fritz Enterprises operates the granulator but Holcim owns the apparatus and markets the slag.

[6] Lafarge grinds some of the granulated slag from East Chicago, IN, at several of its cement plants located elsewhere.

[7] Phoenix Services LLC was awarded the contract for the "west side" at Indiana Harbor in February 2009 and that for the "east side" in August 2009.

[8] Contract was transferred to Stein, Inc. in August 2009.

Soda Ash

By Dennis S. Kostick

Domestic survey data and tables were prepared by Martha L. Jackson, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

The sluggish global economic conditions in the major soda ash-consuming sectors caused domestic sales and export sales to decrease, resulting in lower soda ash production levels. The annual average unit value of soda ash and the unit value of exported material, however, reached record highs in 2009. The total value of U.S. soda ash was $1.33 billion (table 1).

Soda ash, also known as sodium carbonate (Na_2CO_3), is an alkali chemical refined from the mineral trona or naturally occurring sodium carbonate-bearing brines (the soda ash from both is referred to as natural soda ash) or manufactured from one of several chemical processes (the soda ash from this process is referred to as synthetic soda ash).

Soda ash is an important industrial compound used to manufacture chemicals, glass, pulp and paper, soaps and detergents, and many other familiar consumer products. The United States has the world's largest natural deposit of trona and is the world's second ranked soda ash-producing nation. U.S. natural soda ash is extremely competitive in world markets because the majority of the world output of soda ash is made synthetically, which is usually a more expensive process.

Production

Soda ash production and inventory data were collected by the U.S. Geological Survey (USGS) from monthly, quarterly, and annual voluntary surveys of the U.S. soda ash industry. A survey request was sent to each of the five soda ash companies, all of which responded, representing 100% of the total production data in this report (table 1).

The United States remained the world's second ranked soda ash-producing nation in 2009. After more than a century of the United States leading in the world's production of soda ash, China overtook the United States in 2003, and it appeared that China would continue to be the world's leader for the foreseeable future. U.S. production of natural soda ash from California and Wyoming in 2009 was 9.31 million metric tons (Mt). Based on about 14.5 million metric tons per year (Mt/yr) (16 million short tons per year) of total nameplate production capacity, the U.S. soda ash industry operated at 64% of total capacity. This capacity utilization rate appears to be low because it includes the full nameplate capacity of 900,000 metric tons per year (t/yr) (1 million short tons per year) for Solvay Chemicals, Inc.'s Parachute, CO, plant, 816,000 t/yr (900,000 short tons per year) for OCI Chemical Corp.'s, and 726,000 t/yr (800,000 short tons per year) for FMC Corp.'s Granger plant, some of which included nameplate capacity idled in 2009.

Approximately 2.45 Mt/yr of nameplate capacity (2.70 million short tons per year), which represented about 17% of total industry nameplate capacity, was idled in 2009. This available capacity could be brought back online when market conditions improve. The U.S. soda ash industry used the term "effective capacity" to minimize the effect that "mothballed capacity" had on operating rates. This resulted in higher capacity utilization percentages. Individual effective capacity data are not publicly disclosed. Producers use nameplate capacities to determine export allocations set by the export association, the American Natural Soda Ash Corp. (ANSAC).

The U.S. soda ash industry consisted of five companies in 2009—four companies operating five plants in Wyoming that produced soda ash from underground trona ore and one in California that produced soda ash from sodium-carbonate-rich brines. Solvay operated a plant in Wyoming and a plant in Colorado, which was mothballed in September 2004 but continued sodium bicarbonate production using soda ash feedstock from the company's Wyoming soda ash facility.

On February 8, 2008, FMC announced that it planned to recommission its entire mothballed capacity at its Granger soda ash plant by 2012 because of the increased demand in export sales. About 90,700 t/yr (100,000 short tons per year) was expected to restart in 2009, with the remaining 635,000 t/yr (700,000 short tons per year) expected to come online during 2010 to 2012, depending on the export market. In April 2009, however, FMC was forced to temporarily suspend operations at Granger because of the global economic slowdown that affected the export market. In July, FMC announced it would continue to curtail its operations for the remainder of the year and into 2010 (FMC Corp., 2009).

Each of the U.S. companies is either wholly owned or partially owned by foreign soda ash-producing companies or foreign soda ash consumers. The U.S. soda ash industry was 62% foreign owned and 38% domestically owned. At yearend, the countries and percentage ownership were India, 34%; Belgium, 31%; Japan, 18%; and the Republic of Korea, 17% (table 2).

The economic recession that affected many regions of the world resulted in decreased global soda ash consumption, particularly in the glass sectors. In response to reduced consumption, production fell as well. OCI Chemical laid off more than 38 workers at its Wyoming facility in August. FMC laid off 70 workers, including 50 hourly workers and 20 salaried workers, or approximately 8% of the company's soda ash mine workforce (Gearino, 2009).

Consumption

The USGS collects soda ash consumption data by end use on a quarterly basis from the marketing and sales departments of each company. Every effort has been made to categorize company sales within the correct end-use sector. Quarterly reports are often revised in subsequent quarters because of customer reclassifications or other factors. All U.S. soda ash companies responded to the quarterly surveys; data represented 100% of the total reported consumption data found in this report.

In 2009, U.S. apparent consumption and reported consumption were virtually identical. Apparent consumption of soda ash was 4.95 Mt; reported consumption was 5.02 Mt (table 1). Reported consumption and apparent consumption do not necessarily correspond because reported consumption is sales reported by producers, whereas apparent consumption is the calculated quantity available for domestic consumption based on balancing supply (production, imports, and inventory adjustments) with external demand (exports).

When the two types of consumption do not closely correspond, the difference is usually attributed to a discrepancy in the export data that were used to derive consumption statistics. The two sources for export data were the U.S. Census Bureau, which reports exports upon departure from U.S. ports, and the California and Wyoming soda ash producers, which consider shipments to be exported when their export association, ANSAC, takes consignment of the product at the Wyoming plant sites. Transit times between the plant and port, which can be about 2 to 3 weeks before the cargo is actually exported, and carryover export inventories contribute to the discrepancy between reported and apparent consumption as well.

In the domestic market, large-volume buyers of soda ash were primarily the major glass container manufacturers whose purchases were seasonal (more beverage containers are made in the second and third quarters for summertime beverage consumption). Soda ash sales to the flat glass sector depended more on the state of the economy because the leading uses of flat glass were in automobile manufacture and residential housing and commercial building construction. These two major industrial sectors are especially sensitive to changing economic conditions, and soda ash sales follow trends in the two sectors. The distribution of soda ash by end use in 2009 was glass, 47%; chemicals, 29%; soap and detergents, 10%; distributors, 5%; flue gas desulfurization and other uses, 3% each; pulp and paper, 2%; and water treatment, 1% (table 3).

Chemicals.—Soda ash is used to manufacture many sodium-base inorganic chemicals, including sodium bicarbonate, sodium chromates, sodium phosphates, and sodium silicates.

Glass.—Glass manufacture represented about 47% of domestic soda ash consumption as follows: container, 56%; flat, 34%; and fiber, 6%, and other, 4%. Glass containers are made for beverages (beer, carbonated, and noncarbonated drinks), chemical and household products, food, liquor, medical products, and toiletries and cosmetics. In 2009, about 211 million gross units of glass containers were manufactured, of which 59% were for beer bottles, 18% for food containers, 8% for beverage containers, 6% for wine containers, 4% each for liquor and ready-to-drink alcoholic coolers and cocktail containers, and 1% for miscellaneous containers (chemicals, cosmetics, health, household, industrial, medicinal, and toiletries).

Soaps and Detergents.—Detergents were the third ranked use of soda ash. Soda ash was used as a builder to emulsify oil stains, to reduce the redeposition of dirt during washing and rinsing, to provide alkalinity for cleaning, and to soften laundry water. In addition, soda ash was a component of sodium tripolyphosphate (STPP), another major builder in detergent formulations. Soda ash consumption has been decreasing because phosphatic detergents can contribute to eutrophication, which is an environmental concern. Many regions of the Nation have adopted phosphate limitations or bans, affecting about 40% of the U.S. population.

In response to the environmental concern that cardboard detergent packaging contributes to the volume of landfill waste, detergent manufacturers changed formulations to make compact and superconcentrated products. These reformulations required sodium silicates and synthetic zeolites, which are made from soda ash. Liquid detergents, which do not contain any soda ash, competed with powdered detergents and commanded about 5% of the household laundry detergent market in 2009.

Stocks

Yearend 2009 stocks of dense soda ash in domestic plant silos, terminals, warehouses, and on teamtracks amounted to 217,000 metric tons (t). Producers indicated that a potential supply problem could exist if inventories fell below 180,000 t. Most consumers of soda ash did not have the storage facilities to accommodate large quantities of soda ash and had to rely on suppliers to provide the material on a timely basis.

Prices

The annual average value in 2009 for bulk, dense natural soda ash, free on board (f.o.b.) Green River, WY, and Searles Valley, CA, was $143.17 per metric ton ($129.88 per short ton), which was a record high, eclipsing the previous record set in 2008 that was $134.60 per ton ($122.11 per short ton). Part of the price increase was because a few of the low-priced, long-term contracts (legacy agreements) with certain customers expired and were renegotiated at higher prices. The value is not a "price," but rather the value of the combined revenue of California and Wyoming bulk, dense soda ash sold on an f.o.b. plant basis at list, spot, or discount prices, on long-term contracts, and for export, divided by the quantity of soda ash sold. Only merchant soda ash is used to derive the annual value; therefore, no soda ash for value-added products or soda liquors is included. The list prices quoted in trade journals or by producers differed from the annual average values reported to and by the USGS.

In August, FMC announced a soda ash price increase of $10 per short ton effective October 1, 2009, or as contracts allowed. The company stated the increase was necessary to "recover cost increases and to support continued investment in the business." The new list price for bulk, dense soda ash was $260 per short ton (Industrial Minerals, 2009a).

General Chemical (Soda Ash) Partners raised its list price of soda ash on September 4, effective immediately or as contract terms permit, by $10 per short ton to $260 per short ton (General Chemical, 2009).

Because the price of natural gas remained high in 2009, all the producers maintained an energy surcharge on soda ash sales. Depending on the company, the surcharges were adjusted either monthly [based on the last quoted New York Mercantile Exchange (NYMEX) Henry Hub closing price for the next forward month] or quarterly (based on the 3-month forward average NYMEX gas price using the closing price as of the 15th of the month prior to the beginning of each calendar quarter.) The surcharges were expected to remain in effect as long as the price f natural gas was between $5.00 and $8.00 per million British hermal units.

Foreign Trade

The majority of U.S. soda ash exports were controlled by ANSAC, which is involved exclusively in the export trade of soda ash, defined as an alkali product designated by the chemical formula Na_2CO_3, whether manufactured by brine evaporation and purification, Solvay process, trona refining, or ny other means. Under the Treaty of Rome agreement (1958), ANSAC is not permitted to ship soda ash to the European Union EU); however, the members of the U.S. soda ash industry formed another organization for shipping to this region. It is he American-European Soda Ash Shipping Association, Inc. AESSA) that is engaged solely in storage, transportation, and other related logistical and technical support activities o promote and further its members' individual commerce in soda ash being shipped to the EU. Both ANSAC and AESSA were formed as Webb-Pomerene export associations under the authority of the U.S. Federal Trade Commission.

On January 21, Solvay Chemicals announced that it would withdraw from ANSAC effective December 31, 2010. The company indicated that its business had evolved to where the company could logistically and technically serve its customers throughout the world. Solvay joined Searles Valley Minerals as the second domestic soda ash company to leave ANSAC. FMC, General Chemical, and OCI continued to remain as members of the U.S. export association (All Business, 2009).

According to the U.S. Census Bureau, U.S. soda ash exports for 2009 were 4.41 Mt, which represented about 47% of U.S. soda ash production. For comparison, exports accounted for only 5% of U.S. production in 1970, 13% in 1980, 26% in 1990, and 38% in 2000. In 2009, the regional percentage distribution of U.S. exports to 50 countries, was South America, 26%; Asia, 24%; North America, 23%; Europe, 16%; the Middle East, 4%; Africa and Oceania, 3% each; Central America, 1%; and the Caribbean, negligible (table 5). The average free alongside ship value was $190.02 per metric ton in 2009 compared with $174.57 per ton in 2008. Although the data in tables 1 and 6 are rounded to three significant digits, the unit values listed in table 6 are based on the unrounded statistics. The 10 leading countries, representing 67% of total U.S. soda ash exports, in decreasing order and percentage of total were Mexico, 17%; Brazil, 11%; Indonesia, 6%; Canada, 6%; Belgium, 5%; Japan, 5%; Chile, 5%; The Netherlands, 4%; Taiwan, 4%; and Venezuela, 4% (table 6). About 41% of all U.S. soda ash exports went through the Columbia-Snake River customs district in Idaho, Oregon, and Washington, the Port Arthur, TX, customs district was the second-ranked customs district with 30% of the total, and the Laredo, TX, customs district was third with 14% of the total (table 5).

Imports of soda ash decreased slightly to 5,970 t from 12 countries according to U.S. Census Bureau data. In 2009, about 36% of soda ash imports were from the United Kingdom, 25% from China, 14% from Mexico, 5% from Italy, and 3% from Japan. The remaining 17% of imports was from Belgium, Canada, the Dominican Republic, France, Germany, Hong Kong, and India. The Dominican Republic was listed as a source; however, the country does not produce soda ash. It is possible that the entry was erroneous or that the product was transshipped from another location. The average cost, insurance, and freight value of imported soda ash was $356.65 per ton, and the customs value was $295.68 per ton.

World Review

Soda ash is a mature commodity in which consumption tends to grow in proportion to population and gross domestic product growth rates. For this reason, the leading consumers of soda ash were, for the most part, developed nations with lower growth rates compared with those of developing countries. The developing nations tend to use less soda ash than developed nations but have higher growth rates. Although the production and consumption quantities varied among the countries, the end-use patterns were basically the same: glass, chemicals, and detergents were the major sectors.

In 2009, world soda ash production was estimated to be 44.1 Mt, which was a 3% decrease from 2008. Of the 29 countries that produce natural and synthetic soda ash, the United States is the world's second-ranked producer, accounting for 21% of total world output. Only Botswana, China, Ethiopia, Kenya, Turkey, and the United States produce soda ash from natural sources; the remaining 23 nations manufacture soda ash through various chemical processes, primarily the Solvay process. Total world natural soda ash production represented about 23% of combined world soda ash production.

Eight countries produced more than 1 Mt of soda ash annually. They were, in descending order, China, the United States, Russia, India, Turkey, Germany, Poland, and France (table 7). Bulgaria, Romania, and Ukraine had production installations that were rated at about 1 Mt/yr; adverse economic conditions, however, caused these nations to produce below their facilities' design capacities. The five top total soda ash-producing nations accounted for 77% of world production in 2009.

China.—In April, China introduced a 9% rebate on the 17% value-added tax on soda ash exports. The rebate encouraged Chinese exports to overseas markets where it directly competes with ANSAC. The rebate reportedly had also stimulated excessive soda ash capacity expansions in China that had caused Chinese soda ash prices to fall, which in turn placed additional financial pressure on the U.S. soda ash producers by putting downward pressure on prices (Wyoming Business Report, 2009.)

India.—To protect its soda ash industry from imports of less expensive soda ash from China, India's central government imposed a 20% duty on imports of soda ash as recommended by India's Directorate General of Safeguards, which was part of the country's finance ministry. The duty was to remain in effect through April 19, 2010 (Industrial Minerals, 2009b).

Netherlands.—Brunner Mond (UK) Ltd. (owned by Tata Chemicals Ltd. of India) permanently closed its Delfzijl synthetic soda ash plant in May 2009. The company stated that "...the business is forecasting continued heavy losses and, given the current economic downturn, the situation is now unsustainable." The plant had a production capacity of 420,000 t/yr (Industrial Minerals, 2009c).

Turkey.—Eti Soda Inc. (owned 74% by the Ciner Group and 26% by Eti Mine Foundation General Directorate) began production in March at its $375 million natural soda ash facility in

Beypazari. The plant's nameplate capacity was 1 Mt/yr of soda ash and 100,000 t of sodium bicarbonate. The operation uses solution mining technology to recover natural trona from beds in the region that were discovered in 1979 while drilling for coal. About 80% of the soda ash was planned to be exported and 20% was planned to be used for domestic consumption (Ciner Group, 2009).

Outlook

The international economic downturn that began in 2008 affected soda ash-consuming industries throughout 2009. This decrease in soda ash consumption caused domestic and foreign soda ash producers to reduce soda ash production. Because the glass container sector is the leading soda ash-consuming sector, the demand for soda ash for glass containers may decline as consumers increasingly accept their food and beverages packaged in the newer polyethylene terephthalate (PET) containers. Three dominant groups have survived to become the world leaders in soda ash—Solvay S.A. of Belgium, ANSAC of the United States (which represented four of the five domestic producers in 2009), and Chinese producers. India has emerged recently as a major leader in world soda ash production as well and will probably compete in the export markets with the other groups. The new natural soda ash facility in Turkey that came onstream in 2009 may double capacity by 2012 to serve markets in the Middle East and northern Africa. This could result in additional competition in that region for U.S. soda ash producers.

For several years before the recent economic downturn, the strong U.S. economy had boosted demand for industrial and institutional cleaners and automatic dishwashing detergents. New technology incorporating enzymes in dishwashing detergents and a move toward liquid cleansers, however, may adversely affect STPP consumption in the future.

Despite the downturn in the U.S. economy, U.S. soda ash production for the next 3 years is expected to increase. Global economic problems are expected to ease slowly in the next 2 years to stimulate domestic soda ash production and export sales. The United States likely will continue to compete with Chinese soda ash producers in the Far Eastern markets. U.S. soda ash exports in 2010 may increase, causing domestic soda ash production to increase slightly. Increases in world consumption is forecast to range from 2.0% to 2.5% per year for the next several years. Asia and South America remain the likeliest areas for increased soda ash consumption in the near future.

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TABLE 1
SALIENT SODA ASH STATISTICS[1]

(Thousand metric tons and thousand dollars except average annual value)

	2005	2006	2007	2008	2009
United States:					
Production:					
Soda ash:					
Quantity	11,000	11,000	11,100	11,300	9,310
Value	968,000	1,170,000	1,260,000	1,520,000	1,330,000
Value, average annual:					
Per short ton	\$80.19	\$96.64	\$103.53	\$122.11	\$129.88
Per metric ton	\$88.39	\$106.53	\$114.12	\$134.60	\$143.17
Wyoming trona	17,000	16,700	17,200	17,800	15,100
Exports:					
Quantity	4,680	4,820	5,130	5,370	4,410
Value	640,000	736,000	734,000	939,000	838,000
Imports for consumption:					
Quantity	8	7	9	13	6
Value	2,460	2,290	2,760	3,820	2,350
Stocks, December 31, producers'	243	290	206	259	217
Consumption:					
Apparent	6,380	6,100	6,030	5,860	4,950
Reported	6,200	6,110	5,940	5,700 r	5,020
World, production[e]	41,100	42,600	44,900	45,600 r	44,100

[e]Estimated. [r]Revised.

[1] Data are rounded to no more than three significant digits, except average annual value.

TABLE 2
U.S. PRODUCTION OF SODIUM COMPOUNDS, BY MONTH[1]

(Thousand metric tons)

	2008		2009	
	Soda ash	Wyoming trona[2]	Soda ash	Wyoming trona[2]
January	922	1,510	805	1,160
February	878	1,370	670	2,020
March	955	1,510	739	983
April	890	1,530	670	1,080
May	987	1,490	767	1,180
June	935	1,480	734	1,140
July	912	1,200	794	971
August	976	1,630	827	1,220
September	935	1,490	814	1,250
October	996	1,560	812	1,360
November	965	1,530	826	1,340
December	917	1,510	854	1,380
Total	11,300	17,800	9,310	15,100

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes solution-mined trona.

TABLE 3
U.S. PRODUCERS OF SODA ASH IN 2009

(Million short tons unless otherwise noted)

Company	Plant nameplate capacity	Plant location	Source of sodium carbonate
FMC Wyoming Corp.:			
Granger	1.30	Granger, WY	Underground trona.
Green River[1]	3.55	Green River, WY	Do.
General Chemical (Soda Ash) Partners[2]	2.80	do.	Do.
OCI Chemical Corp.[3]	3.10	do.	Do.
Searles Valley Minerals, Inc.[4]	1.45	Trona, CA	Dry lake brine.
Solvay Chemicals, Inc.:[5]			
Green River	2.80	Green River, WY	Underground trona.
Parachute[6]	1.00	Parachute, CO	Underground nahcolite.
Total	16.00		
Total million metric tons	14.50		

Do., do. Ditto.

[1] Formed joint venture (20%) in February 1996 with Sumitomo Corp. and Nippon Sheet Glass Co., Ltd., both of Japan.

[2] A joint venture between General Chemical Corp. (75%) and Owens-Illinois, Inc. (25%). Tata Chemicals Ltd. of India in January 2008 purchased the 75% share of General Chemical Industrial Products, Inc.

[3] Owned by DC Chemical Co., Ltd. of the Republic of Korea (51%) and Anadarko Petroleum Corp. (49%). An 800,000-short-ton expansion brought onstream in November 1998 increased plant capacity to 3.1 million short tons per year; however, the company took 900,000 short tons per year out of service temporarily for equipment refurbishment.

[4] The operation was sold to Nirma Ltd. of India in November 2007.

[5] Solvay Soda Ash Joint Venture is owned by Solvay S.A. of Belgium (80%) and Asahi Glass Co. of Japan (20%).

[6] Operation purchased on September 10, 2003, from American Soda L.L.P. Soda ash plant idled indefinitely.

TABLE 4

REPORTED CONSUMPTION OF SODA ASH IN THE UNITED STATES, BY END USE, BY QUARTER[1]

(Thousand metric tons)

NAICS[2] code	End use	2008	2009 First quarter	2009 Second quarter	2009 Third quarter	2009 Fourth quarter	2009 Total
3272	Glass:						
327213	Container	1,400 [r]	322	345	345	306	1,320
327211	Flat	1,020	189	190	208	214	800
327993	Fiber	186	35	30	38	38	141
327212	Other	140 [r]	26	29	28	29	111
	Total	2,740 [r]	572	593	619	586	2,370
32518	Chemicals	1,670 [r]	326	361	379	368	1,430
325611	Soaps and detergents	501 [r]	123	121	129	135	508
322	Pulp and paper	93 [r]	30	26	24	23	103
221310	Water treatment[3]	58 [r]	11	11	13	14	49
56221	Flue gas desulfurization	131	38	32	40	42	152
422	Distributors	317 [r]	62	64	65	57	249
	Other	187 [r]	35	36	34	52	156
	Total domestic consumption[4]	5,700 [r]	1,200	1,250	1,300	1,280	5,020
	Exports[5]	5,420 [r]	967	974	1,220	1,360	4,520
	Canada	326 [r]	62	56	70	64	252
	Total industry sales[6]	11,100 [r]	2,160	2,220	2,520	2,640	9,540
	Total sales from plants	11,200	2,200	2,190	2,510	2,550	9,450
	Total production	11,300	2,210	2,170	2,440	2,490	9,310

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] North American Industry Classification System.

[3] Includes soda ash equivalent from soda liquors and purge liquors sold to powerplant for water treatment. Sales of mine water are excluded.

[4] Imports reported by the producer/importer have been distributed into appropriate end-use categories listed above.

[5] As reported by producers; includes Canada. Data may not necessarily agree with those reported by the U.S. Census Bureau for the same periods.

[6] Represents soda ash from domestic origin (production and inventory changes) and imports and exports. Includes soda ash sold by coproducers and distributed by purchasers into appropriate end-use categories.

TABLE 5
REGIONAL DISTRIBUTION OF U.S. SODA ASH EXPORTS, BY CUSTOMS DISTRICTS, IN 2009[1]

(Metric tons)

Customs districts	North America	Central America	South America	Caribbean	Europe	Middle East	Africa	Asia	Oceania	Total	Percentage of total
Atlantic:											
Baltimore, MD	--	--	--	--	18	--	--	--	--	18	(2)
Charleston, SC	--	--	--	--	223	--	--	--	--	223	(2)
Miami, FL	--	11	85	39	--	39	--	--	--	174	(2)
New York, NY	--	--	20	--	594	--	--	4	--	618	(2)
Norfolk, VA	--	--	--	--	189	--	--	--	--	189	(2)
Savannah, GA	--	--	--	--	98	--	--	--	--	98	(2)
Gulf:											(2)
Houston-Galveston, TX	--	--	305	5	141	--	82	--	--	533	(2)
New Orleans, LA	--	7	--	--	--	--	--	--	--	7	(2)
Port Arthur, TX	--	18,100	688,000	5,630	488,000	5,680	115,000	--	--	1,320,000	30
North-central:											(2)
Cleveland, OH	277	--	--	--	--	--	--	--	--	277	(2)
Detroit, MI	194,000	--	--	--	--	--	--	--	--	194,000	4
Duluth, MN	5,910	--	--	--	--	--	--	--	--	5,910	(2)
Great Falls, MT	27,900	--	--	--	--	--	--	--	--	27,900	1
Pembina, ND	3,770	--	--	--	--	--	--	--	--	3,770	(2)
Northeast:											(2)
Buffalo, NY	12,500	--	--	--	--	--	--	--	--	12,500	(2)
Ogdensburg, NY	930	--	--	--	--	--	--	--	--	930	(2)
Portland, ME	63	--	--	--	--	--	--	--	--	63	(2)
St. Albans, VT	50	--	--	--	--	--	--	--	--	50	(2)
Pacific:											(2)
Anchorage, AK	9,270	--	--	--	--	--	--	--	--	9,270	(2)
Columbia-Snake River, ID-OR-WA	--	42,500	201,000	--	208,000	175,000	--	1,050,000	111,000	1,790,000	41
Los Angeles, CA	--	--	237,000	--	19,100	--	--	5,120	5,150	267,000	6
San Diego, CA	54,300	--	--	--	--	--	--	--	--	54,300	1
San Francisco, CA	--	--	--	--	--	--	--	18	--	18	(2)
Seattle, WA	17,100	--	--	--	--	--	--	--	--	17,100	(2)
Southwest:											(2)
El Paso, TX	105,000	--	--	--	--	--	--	--	--	105,000	2
Laredo, TX	598,000	--	--	--	--	--	--	--	--	598,000	14
Nogales, AZ	10	--	--	--	--	--	--	--	--	10	(2)
Unknown	316	--	--	--	--	--	--	--	--	316	(2)
Total	1,030,000	60,600	1,130,000	5,670	717,000	180,000	115,000	1,060,000	117,000	4,410,000	100
Percentage of total	23	1	26	(2)	16	4	3	24	3	100	XX

XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau, as adjusted by the U.S. Geological Survey, using data and information from the Journal of Commerce PIERS trade service and industry sources.

TABLE 6
U.S. EXPORTS OF SODA ASH, BY COUNTRY[1]

	2008			2009		
Country	Quantity (thousand metric tons)	Value[2] (thousands)	Unit value	Quantity (thousand metric tons)	Value[2] (thousands)	Unit value
Andorra	(3)	$27	$150	--	--	--
Angola	(3)	32	169	--	--	--
Argentina	110	22,900	208	116	$24,500	$211
Aruba	(3)	7	553	--	--	--
Australia	136	27,100	198	92	20,200	220
Bahrain	1	391	357	--	--	--
Belgium	185	27,200	147	234	36,500	156
Brazil	646	123,000	191	506	104,000	205
Canada	389	57,600	148	272	56,700	208
Chile	301	53,200	177	212	41,600	196
China	(3)	93	484	32	2,070	65
Colombia	120	19,700	165	68	13,800	203
Costa Rica	25	4,750	190	27	7,010	260
Dominican Republic	4	1,670	374	6	1,500	250
Ecuador	17	2,900	166	23	5,430	236
El Salvador	8	1,430	188	6	1,320	220
France	59	8,220	140	56	7,920	141
Guatemala	51	10,000	198	19	4,150	218
India	--	--	--	3	660	220
Indonesia	343	64,900	189	282	41,800	148
Italy	1	195	329	10	1,730	173
Jamaica	(3)	13	524	--	--	--
Japan	211	32,700	155	213	41,200	193
Korea, Republic of	140	30,200	216	138	25,100	182
Lithuania	118	16,100	136	72	10,200	142
Malaysia	75	17,200	227	31	5,990	193
Mexico	1,000	170,000	169	758	171,000	225
Morocco	1	255	189	--	--	--
Netherlands	123	20,200	164	166	28,600	172
New Zealand	28	5,520	199	25	5,010	200
Nicaragua	(3)	6	110	--	--	--
Nigeria	(3)	5	439	--	--	--
Oman	1	323	344	--	--	--
Panama	13	2,540	197	9	2,100	233
Peru	40	7,400	186	43	9,110	212
Philippines	54	10,200	190	43	6,250	145
Portugal	29	3,270	112	62	7,560	122
Qatar	(3)	5	837	--	--	--
Saudi Arabia	140	24,200	173	117	20,300	173
Senegal	(3)	16	583	--	--	--
Singapore	(3)	71	764	2	211	106
Slovakia	(3)	29	498	--	--	--
South Africa	93	15,100	163	82	13,300	162
Spain	103	14,200	138	116	17,300	149
Taiwan	233	42,100	181	160	25,200	157
Thailand	145	25,200	173	148	24,200	163
Tunisia	--	--	--	33	3,760	114
United Arab Emirates	101	17,400	172	58	11,400	196
Venezuela	297	54,100	182	158	38,900	246
Vietnam	20	4,810	240 r	6	823	137
Other	5	463	182	5	801	160
Total	5,370	939,000	175	4,410	838,000	190

See footnotes at end of table.

TABLE 6—Continued
U.S. EXPORTS OF SODA ASH, BY COUNTRY[1]

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[r]Revised. -- Zero.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Free alongside ship value.

[3] Less than ½ unit.

Source: U.S. Census Bureau, as adjusted by the U.S. Geological Survey, using data and information from the Journal of Commerce Port Import-Export Reporting Service and industry sources.

TABLE 7
SODA ASH: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2005	2006	2007	2008	2009
Argentina	86 [4]	161 [4]	-- [r]	-- [r]	--
Australia	300	310	310	310	310
Austria[5]	100	-- [r]	--	--	--
Bosnia and Herzegovina	11	11	11	11	11
Botswana[6]	250	250	250	250	250
Brazil	200	200	200	200	200
Bulgaria	800	800	800	800	800
Chad[7]	12	12	12	12	12
China	14,210 [4]	15,600 [4]	17,720 [4]	18,540 [r, 4]	19,350 [4]
Egypt	50	50	50	50	50
Ethiopia[8]	8 [4]	4	(9) [r, 4]	2 [r, 4]	2
France	1,000	1,000	1,000	1,000	1,000
Germany	1,533 [4]	1,515 [4]	1,510 [4]	1,567 [r, 4]	1,300
India	1,500	1,500	1,500	1,500	1,500
Iran	130	130	140	140	140
Italy	525	500	500	500	500
Japan	400	400	400	400	400
Kenya[6]	360 [4]	374 [4]	387 [4]	513 [4]	405 [4]
Korea, Republic of	310	310	310	310	310
Mexico	290	290	290	290	290
Netherlands	400	400	400	400	400
Pakistan	260	250	260	250	260
Poland	1,189 [4]	1,177 [4]	1,192 [4]	1,190 [r]	1,200
Portugal	150	150	150	150	150
Romania	346	453	453	450	450
Russia	2,600	2,800	2,900	2,800	2,300
Spain	500	500	500	500	500
Turkey[10]	869 [4]	891 [4]	947 [4]	950	1,500
Ukraine	700	700	700	700	700
United Kingdom	1,000	900	900	500	500
United States[6]	11,000 [4]	11,000 [4]	11,000 [4]	11,300 [4]	9,310 [4]
Total	41,000 [r]	42,600	44,900	45,600 [r]	44,100

[r]Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through April 11, 2010. Synthetic unless otherwise specified.

[3] In addition to the countries listed, Tanzania may produce soda ash for local consumption; available general information is inadequate for the formulation of reliable estimates of output levels.

[4] Reported figure.

[5] Plant closed in mid-2005; production discontinued.

[6] Natural only.

[7] Produced for local consumption only.

[8] Data for the Ethiopian calendar year ending July 2007 of the year listed.

[9] Less than ½ unit.

[10] Production of natural soda ash from Beypazari deposit began in early 2009.

STONE, CRUSHED

By Jason Christopher Willett

Domestic survey data and tables were prepared by Susan M. Weaver, statistical assistant.

A total 1.17 billion metric tons (Gt) of crushed stone was produced for consumption in the United States in 2009, nearly 20% less than the total production of 2008 and 34% less than the record high of 1.78 Gt in 2006. This was the lowest level of crushed stone produced for consumption in the United States since 1993. In 2009, the total value of crushed stone produced in the United States was $11.3 billion, a decrease of 17% compared with that of 2008 (table 1). The average unit price for crushed stone increased 4% compared with the average unit price for 2008 and increased 13% compared with that of 2007. The increase in unit prices partially offset the impact of the large decrease in production, but the total value of the crushed stone produced in 2009 was only about the same as the total value in 1996.

About 68% of crushed stone production continued to be limestone and dolomite, followed by (in descending order of tonnage) granite, miscellaneous stone, traprock, sandstone and quartzite, volcanic cinder and scoria, marble, calcareous marl, slate, and shell (table 2).

Foreign trade in crushed stone remained relatively small compared to nationwide consumption. In 2009, U.S. exports increased slightly to 1.26 million metric tons (Mt) compared with 1.24 Mt in 2008, but the value decreased by 5% to $58.3 million, compared with $61.6 million in 2008 (tables 1, 17). U.S. imports of crushed stone, including calcium carbonate fines, decreased by 41% to 12.2 Mt, and the value decreased by 25% to $174 million compared with the 2008 totals (tables 1, 18). Apparent domestic consumption of crushed stone, which is defined as production for consumption (sold or used) plus recycling and imports minus exports, decreased by 20% to 1.21 Gt compared with 1.51 Gt in 2008 because of lower demand resulting from the U.S. economic recession.

Stone is one of the most accessible natural resources of the Earth and one of the fundamental building blocks of society. It has been used from the earliest times of civilization for a variety of uses that have increased in number and complexity with time and technological progress. Today, in its crushed form, stone is a major basic raw material for the construction industry, as well as agriculture and other industries that use complex chemical and metallurgical processes. Despite the relatively low, but increasing, unit value of its basic products, the crushed stone industry is a major contributor to and an indicator of the economic well-being of the Nation. Construction aggregates are defined as the combination of crushed stone and construction sand and gravel. The construction sand and gravel industry is reviewed in a separate chapter, and both mineral commodities are usually included in any review of the national or State aggregates industry.

Production

Domestic production data for crushed stone were derived by the U.S. Geological Survey (USGS) from voluntary surveys of U.S. producers. In 2009, a total of 1,606 companies produced or sold crushed stone from 3,788 operations with 3,968 quarries and 195 sales and (or) distribution sites. Of the 3,788 active operations, 2,272 operations reported their production or sales to the USGS, and their total production was 819 Mt (70% of the U.S. total). Of the 2,272 reporting operations, 1,155 operations owned by 306 companies did not report a breakdown by end use. Their total production was 432 Mt (37% of the U.S. total) and is included in table 9 under "Unspecified, reported" uses.

Production of the nonresponding quarries was estimated by using employment data provided by the Mine Safety and Health Administration (MSHA). The estimated output of 1,510 nonrespondent operations owned by 971 companies was 346 Mt (30% of the U.S. total) and is included in table 9 under "Unspecified, estimated" uses.

A total of 195 sales yards were active in 2009, and their total output was 39.0 Mt. Information regarding the number of active operations, including recycling operations, active quarries, type of processing plants, and number of sales yards by State is provided in table 16.

Crushed stone was produced in every State except Delaware. Starting with 2005, Delaware's production is included in the U.S. total because of sales yards that reported sales of crushed stone in the State. The 10 leading producing States were, in descending order of tonnage, Texas, Pennsylvania, Missouri, Illinois, Florida, Georgia, Kentucky, Indiana, Ohio, and Virginia. The combined production of the 10 leading States decreased by 21% and was 584 Mt, one-half of the national total.

There are 91 underground mines included in the total number of active operations, and they produced 65.1 Mt of crushed stone in 2009. Active underground mines were located in 17 States. The five leading States were, in descending order of tonnage, Kentucky, Illinois, Missouri, Pennsylvania, and Iowa. Their combined production was 46.6 Mt (72% of the total U.S. crushed stone produced underground).

A total of 939 operations were either idle or presumed to have been idle in 2009 because no production report was received, and no employment information was available to estimate their production. Since the 2008 survey, 255 operations have closed. Most of the idle or closed operations were small, temporary quarries, some of which were operated by State or local governments. Operations in U.S. territories are not included in the above count.

Of the total 1.17 Gt of crushed stone produced for consumption in the United States in 2009, 68% was limestone and dolomite; 14% was granite; 6% was traprock; 5% was miscellaneous stone; and 4% was sandstone and quartzite. The remaining 3% was shared, in descending order of tonnage, by marble, volcanic cinder and scoria, slate, calcareous marl, and shell. These percentages were calculated on the total amount of crushed stone produced for consumption that was reported, including individual amounts that were withheld to avoid disclosing company proprietary data.

A review of production by size of operation at the national level indicates that, in 2009, 436 Mt of crushed stone (37% of the total crushed stone) was produced by 260 operations reporting production of more than 1 million metric tons per year; 304 Mt was produced by 490 operations reporting production between 500,000 and 999,999 metric tons per year (t/yr); and 376 Mt was produced by 1,598 operations reporting production between 100,000 and 499,999 t/yr. The production by size of operation information also indicates that 63% of total crushed stone produced in the United States in 2009 came from operations that produced more than 500,000 t/yr (table 5a). By geographic region, in 2009, the South had 1,336 active operations, followed by the Midwest with 1,093, the West with 801, and the Northeast with 587 active operations (table 5b).

The leading U.S. producing companies in 2009 were, in descending order of tonnage, Vulcan Materials Co.; Martin Marietta Aggregates; Lehigh Hanson, Inc.; Oldcastle Materials, Inc.; CEMEX S.A.B. de C.V.; Lafarge North America Inc.; Rogers Group, Inc.; Holcim Group/Aggregate Industries Management, Inc.; Carmeuse Lime & Stone; and New Enterprise Stone & Lime Co., Inc. The combined production of the top 10 companies was 513 Mt (44% of the national total). The combined production of the top 100 companies was 837 Mt (72% of the national total).

Merger and acquisition activity in the U.S. construction aggregates industry, after the huge acquisitions that took place in 2007, slowed to a much lower level in 2008 and virtually came to a stop by the start of 2009. The lack of activity continued through 2009 as companies focused resources on restructuring debt, raising capital, and strengthening core assets (Aggregates Manager, 2010).

Production of crushed stone by type is detailed below.

Calcareous Marl.—Output of calcareous marl decreased 29% compared with that of 2008 to 2.5 Mt valued at $14.0 million (table 2).

Dolomite.—Production of dolomite decreased by 23% compared with the total for 2008 to 45.7 Mt valued at $447 million (table 2). Crushed dolomite production was reported in 25 States. The leading producing States were, in descending order of tonnage, Illinois, Pennsylvania, New York, Michigan, and Indiana; the total production of these five States was 38.9 Mt (85% of the U.S. output) (table 6). An additional undetermined amount of dolomite is included in the total crushed limestone, as explained in the limestone portion of the "Production" section.

Granite.—The output of crushed granite decreased by 23% compared with that of 2008 to 155 Mt valued at $1.9 billion (table 2). Crushed granite was reported as being produced in 34 States. The leading producing States were, in descending order of tonnage, Georgia, North Carolina, Virginia, South Carolina, and California; the total production of these five States was 107 Mt (69% of the U.S. output) (table 7).

Limestone.—The output of crushed limestone, including some dolomite, decreased by 21% compared with that of 2008 to 747 Mt valued at $6.6 billion (table 2). Limestone was reported as being produced in 47 States, and companies in 24 States reported producing limestone and dolomite from the same quarries. Their production of about 18.6 Mt of limestone and dolomite combined is included with the limestone listed in table 2. The limestone totals listed in this chapter, therefore, include an undetermined amount of dolomite in addition to the dolomite reported separately. The leading producing States were (in descending order of tonnage) Texas, Missouri, Florida, Pennsylvania, Illinois, and Kentucky; the total production of these six States was 343 Mt (46% of the total U.S. output) (table 6).

Marble.—Production of crushed marble increased by 51% compared with the total for 2008 to 5.5 Mt valued at $81.7 million (table 2). Crushed marble production was reported in 16 States.

Miscellaneous Stone.—This category includes three different types of miscellaneous crushed stone production. The first type is a crushed stone which is reported by the company as "other" on the survey form or as a type of stone not listed on table 2. The second type is production of unknown stone type from a company or operation that is new to the survey. The first year a new operation is on the survey, it usually does not respond, and its production must be estimated using MSHA employment data. The type of stone produced is updated when a response is received from the operation and the data are revised for the next report. The third type is production of a known rock type when the amount reported must be withheld to protect company proprietary data. The concealed amount is added to the quantity of miscellaneous stone produced in that State and then published.

The output of miscellaneous stone decreased by 8% compared with the total for 2008 to 85.4 Mt, valued at $806 million (table 2). In 2009, the reported amount of miscellaneous stone accounted for 75% of the total output of miscellaneous stone and 69% of its value. The remaining 25% (21.7 Mt) of the total output consisted of known stone for which data were withheld. Of the 21.7 Mt, 68% was limestone, granite, and marble, with the remaining 32% consisting of (in descending order of tonnage) traprock, sandstone and quartzite, slate, volcanic cinder and scoria, shell, and calcareous marl.

Sandstone and Quartzite.—The output of crushed sandstone and quartzite decreased by 9% compared with the total for 2008 to 43.9 Mt, valued at $414 million (table 2). Crushed sandstone production was reported in 30 States, while quartzite was produced in 16 States. The leading producing States were (in descending order of combined tonnage of sandstone and quartzite) Pennsylvania, Arkansas, Texas, New York, and South Dakota. Their combined total production was 28.9 Mt (66% of the U.S. output) (table 7).

Shell.—Shell is derived mainly from fossil reefs or oyster shell banks. The output of crushed shell decreased by 13% compared with the total for 2008 to 0.4 Mt, valued at $5.3 million (table 2). Crushed shell was reported as being produced in 2 States.

Slate.—The output of crushed slate decreased by 35% compared with that of 2008 to 2.4 Mt, valued at $22.8 million (table 2). Crushed slate was produced in 11 States, with Pennsylvania accounting for about 37% of the total U.S. output.

Traprock.—Production of crushed traprock decreased by 28% compared with the total for 2008 to 70.3 Mt, valued at $957 million (table 2). Traprock was reported as being produced in 30 States. The leading producing States were (in descending order f tonnage) New Jersey, Virginia, Oregon, Washington, and ennsylvania; these five States produced 33.7 Mt (48% of U.S. output) (table 7).

Volcanic Cinder and Scoria.—Production of volcanic cinder nd scoria increased by 42% compared with the total for 2008 o 8.2 Mt, valued at $46.7 million (table 2). Volcanic cinder nd scoria production was reported in 13 States, with the top producing State of Wyoming accounting for 84% of U.S. output table 8).

Consumption

Crushed stone production reported to the USGS is actually naterial that was either sold to other companies or consumers or was used by the producers. Stockpiled production is not ncluded in the reported quantities. The "sold or used" tonnage, herefore, represents the amount of production released for domestic consumption or export in a given year. Because some of the crushed stone producers did not report a breakdown by end use, their total production is included in the "Unspecified, reported" use category. The estimated production of nonrespondents is included in the "Unspecified, estimated" use category.

In 2009, U.S. apparent consumption of crushed stone, which is defined as U.S. production plus imports and recycled material minus exports, was 1.21 Gt, a 20% decrease compared with the apparent consumption in 2008. Of the 1.21 Gt of crushed stone consumed, 307 Mt (25%) was "Unspecified, reported," and 346 Mt (29%) was "Unspecified, estimated." Of the remaining consumption reported by uses, 82% was used as construction aggregate, mostly for highway and road construction and maintenance, as well as for a wide variety of building and other nonbuilding construction; 10% for cement manufacturing; 2% for lime manufacturing; 2% for agricultural uses; and 4% for special and miscellaneous uses and products (table 9). Where end uses were unspecified, quantities were redistributed to end uses according to the distributions of reported data.

In 2009, the value of the total construction put in place decreased by 15% compared with that of 2008 to $908 billion, as reported by the U.S. Census Bureau (2010). The value of total private construction decreased by 22% to $592 billion, while the value of total public construction increased slightly to $315 billion. The value of private construction dropped to its lowest level since 1999.

Additional information regarding production and consumption of crushed stone by type of rock and major uses in each State and the State districts may be found in the USGS Minerals Yearbook, volume II, Area Reports: Domestic.

Recycling

The recycling of many materials is increasing, and aggregates producers are increasingly recycling more cement concrete and asphalt concrete materials recovered from construction projects to be reused to produce aggregate materials, especially fill and road base. The recycling of cement concrete is done at some quarries and increasingly at sales yards or distribution sites, whereas asphalt concrete often is recycled in place.

Recycled Asphalt.—Companies in 49 States reported a total of 16.0 Mt of recycled asphalt, valued at $169 million in 2009 (table 14). The leading recycling States were (in descending order of tonnage) California, Illinois, Kansas, Pennsylvania, and Florida. Their combined total was 6.4 Mt, an increase of 26% compared with their combined total of 2008.

Recycled Concrete.—A total of 13.0 Mt of recycled concrete valued at $102 million was reported as recycled in 49 States (table 15). The leading recycling States for 2009 were (in descending order of tonnage) California, Illinois, Michigan, Texas, and Minnesota. Their combined total was 5.6 Mt, a decrease of 22% compared with their combined total of 2008.

Prices

Prices in this chapter are the annual average free on board plant prices, usually at the first point of sale or captive use, as reported by the crushed stone producing companies. This value does not include transportation from the plant or yard to the consumer. It does, however, include all costs of mining, processing, in-plant transportation, overhead costs, and profit. In 2009, 832 operations responding to the annual survey reported the dollar value of their production for the current and previous year. The average unit value for operations reporting production and value was $9.92 per metric ton in 2009. This was an increase of 3% compared with the average unit value of $9.66 per ton in 2008. The annual reports of the top U.S. producing companies reported nearly a 2% to 3% price increase in 2009, compared with prices in 2008. For those operations that reported production only, the unit values of total production or specific end uses were estimated based on what other operations in the same State reported. The average unit value for specific end uses within a State was used in the estimation of value for operations reporting specific end uses. The State average was used in the estimation for operations reporting total production but not total value.

Additional information regarding prices of crushed stone by type of rock and uses in the United States and each State and the State districts may be found throughout the tables included in this chapter and in the USGS Minerals Yearbook, volume II, Area Reports: Domestic.

Transportation

For 702 Mt of the 1.17 Gt of crushed stone produced for consumption in 2009, no means of transportation was reported by the producers. Of the remaining 464 Mt of crushed stone, 75% was reported as being transported by truck from the quarry or the processing plant to the first point of sale or use; 7% by rail, and 7% by waterway. About 41.6 Mt of the specified production was reported as not having been transported and, therefore, is assumed to have been used onsite.

Shipment by truck remains the most widely used method of transportation for crushed stone. The significant increase in the number of sales and distribution yards in the past few years and the increase in the volume of crushed stone going through these sites have had a positive impact on the industry and the communities they serve. Distribution sites, supplied by rail or waterway, are located near metropolitan areas and significantly reduce the distance most trucks must travel to pick up and deliver crushed stone. Therefore, the transportation costs are reduced, as is the impact of heavy traffic on the infrastructure and the environment. Sales yards serve to distribute products and, increasingly, also serve as recycling sites.

Foreign Trade

The widespread distribution of domestic deposits of stone suitable for mining as crushed stone, the large number of existing active operations around the country, and the high cost of transportation limit foreign trade to mostly local transactions across international boundaries. U.S. imports and exports continue to be small, representing slightly more than 1% of domestic consumption.

Information on imports of crushed stone used for this report was derived from two sources. The primary source was import and export data from the U.S. Census Bureau (tables 1, 17–18). Additionally, companies also provided import data when reporting the amount sold or used for consumption at each operation, usually a sales yard. The tonnage reported was attributed to the State where it was first sold or used; for example, crushed stone imported to Florida from Mexico was counted in the total of crushed stone sold or used in Florida (table 4). This was the same accounting practice used for large amounts of crushed stone which were transported from one State to another. For example, crushed stone mined in Kentucky and shipped down the Mississippi River to be used in Louisiana was included in the total of crushed stone sold or used in Louisiana.

Exports.—Exports of crushed stone increased slightly to 1.26 Mt compared with the total of 1.24 Mt in 2008, but the value decreased by 5% to $58.3 million. In 2009, exports of crushed limestone for cement manufacturing averaged a unit value of $24.96 per ton (table 17).

Imports.—Imports of crushed stone decreased by 41% to 12.2 Mt compared with those of 2008, and the value decreased by 25% to $174 million. Of the imported crushed stone, almost all of the limestone was used as construction aggregate, as flux stone, and in cement manufacturing (table 18).

Outlook

The crushed stone industry is a cyclical business, reacting to the levels of activity in public infrastructure projects, commercial and residential construction markets, and other types of construction. The residential construction slowdown in the United States was well documented and contributed to decreased consumption of crushed stone. By almost any economic measure, 2009 was an extremely difficult year for the construction industry. The decline in residential construction was expected to level off in 2010.

Many construction aggregates producers expect that their production levels would start to recover in 2010 and are cautiously predicting that demand could be flat or increase slightly. If demand does increase in 2010, it is predicted to increase at the historical average of the last 50 years or 2% to 4% from the 2009 level. Recovery or growth in demand is expected to be from stimulus-related construction activity and improvements in residential construction. In the past, industry experts have indicated that crushed stone consumed in commercial construction combined with State highway and infrastructure projects would help offset any of the continuing decrease in demand of residential construction. For 2010, it is predicted that if commercial construction remains at current levels, then infrastructure investments will drive the recovery.

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TABLE 1

SALIENT CRUSHED STONE STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2005	2006	2007	2008	2009
Sold or used by producers:[2]					
Quantity	1,700,000	1,780,000	1,650,000	1,460,000[r]	1,170,000
Value	12,400,000	14,300,000	14,100,000	13,600,000[r]	11,300,000
Recycle:					
Quantity	14,400	15,400	20,100	29,100[r]	29,000
Value	99,200	111,000	150,000	252,000[r]	272,000
Exports:					
Quantity	1,260	1,140	1,020	1,240	1,260
Value	50,500	57,300	62,500	61,600	58,300
Imports for consumption:[3]					
Quantity	21,000	19,800	19,500	20,900	12,200
Value	194,000	206,000	212,000	232,000	174,000

[r] Revised.

[1] Data are rounded to no more than three significant digits.

[2] Does not include American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands.

[3] Excludes precipitated calcium carbonate.

TABLE 2

CRUSHED STONE SOLD OR USED IN THE UNITED STATES, BY TYPE[1, 2]

	2008				2009			
Type	Number of quarries	Quantity (thousand metric tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand metric tons)	Value (thousands)	Unit value
Limestone[3]	2,250[r]	944,000[r]	$8,110,000[r]	$8.60[r]	2,147	747,000	$6,620,000	$8.87
Dolomite	136[r]	59,400[r]	529,000[r]	8.91[r]	124	45,700	447,000	9.77
Marble	11[r]	3,600[r]	53,500[r]	14.89[r]	27	5,450	81,700	15.01
Calcareous marl	3	3,500	19,700	5.62	3	2,480	14,000	5.62
Shell	3	475	3,710	7.82	5	414	5,310	12.82
Granite	412[r]	200,000[r]	2,310,000[r]	11.53[r]	407	155,000	1,890,000	12.20
Traprock	367[r]	97,200[r]	1,240,000[r]	12.76[r]	330	70,300	957,000	13.61
Sandstone and quartzite[4]	213[r]	48,100[r]	453,000[r]	9.41[r]	215	43,900	414,000	9.43
Slate	44[r]	3,630[r]	32,300[r]	8.90[r]	34	2,380	22,800	9.57
Volcanic cinder and scoria	45[r]	5,770[r]	43,200[r]	7.48[r]	42	8,170	46,700	5.72
Miscellaneous stone	592[r]	92,600[r]	845,000[r]	9.13[r]	634	85,400	806,000	9.44
Total or average	XX	1,460,000[r]	13,600,000[r]	9.36[r]	XX	1,170,000	11,300,000	9.70

[r] Revised. XX Not applicable.

[1] Data are rounded to no more than three significant digits, except unit values and number of quarries; may not add to totals shown.

[2] Does not include American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands.

[3] Includes limestone-dolomite reported with no distinction between the two kinds of stone.

[4] Includes sandstone-quartzite reported with no distinction between the two kinds of stone.

TABLE 3
CRUSHED STONE SOLD OR USED IN THE UNITED STATES, BY GEOGRAPHIC DIVISION[1, 2]

(Thousand metric tons and thousand dollars)

Region/division	2008[r] Quantity	2008[r] Value	2009 Quantity	2009 Value
Northeast:				
New England	37,600	385,000	34,100	376,000
Middle Atlantic	160,000	1,680,000	135,000	1,510,000
Total	197,000	2,060,000	169,000	1,880,000
Midwest:				
East North Central	226,000	1,780,000	187,000	1,500,000
West North Central	162,000	1,340,000	138,000	1,240,000
Total	388,000	3,130,000	325,000	2,750,000
South:				
South Atlantic	310,000	3,690,000	228,000	2,860,000
East South Central	153,000	1,340,000	124,000	1,220,000
West South Central	237,000	1,800,000	183,000	1,400,000
Total	700,000	6,830,000	535,000	5,470,000
West:				
Mountain	71,100	545,000	57,700	440,000
Pacific	102,000	1,080,000	79,800	764,000
Total	173,000	1,620,000	138,000	1,200,000
Grand total	1,460,000	13,600,000	1,170,000	11,300,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Does not include American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands.

TABLE 4
CRUSHED STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE AND TERRITORIES[1]

State	2008[r] Quantity (thousand metric tons)	2008[r] Value (thousands)	2008[r] Unit value	2009 Quantity (thousand metric tons)	2009 Value (thousands)	2009 Unit value
Alabama	50,000 [2]	$370,000	$7.40	36,400	$332,000	$9.11
Alaska	1,990	31,400	15.81	1,940	34,800	17.93
Arizona	15,300	153,000	9.97	9,120	80,000	8.77
Arkansas	32,200 [2]	241,000	7.49	30,000	217,000	7.23
California	51,400	572,000	11.13 [2]	41,400	378,000	9.13
Colorado	9,590	71,300	7.44	6,970	63,200	9.06
Connecticut	9,640	106,000	10.95	8,030	101,000	12.53
Delaware[3]	W	W	W	W	W	W
Florida	68,400	894,000	13.06	48,600	643,000	13.23
Georgia	61,900 [2]	666,000 [2]	10.76 [2]	45,100	518,000	11.49
Hawaii	7,410	134,000	18.04	5,920	101,000	17.07
Idaho	5,950	38,800	6.51 [2]	4,410	30,800	7.00
Illinois	67,600	613,000	9.07 [2]	56,500	513,000	9.07
Indiana	51,800	352,000	6.79	44,100	290,000	6.57
Iowa	38,700	312,000	8.05	32,600	297,000	9.12
Kansas	23,100	180,000 [2]	7.80 [2]	17,200	143,000	8.34
Kentucky	52,700	422,000	8.02	44,300	389,000	8.78
Louisiana[3]	W	W	W	W	W	W

See footnotes at end of table.

TABLE 4—Continued

CRUSHED STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE AND TERRITORIES[1]

	2008[r]			2009		
State	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value
Maine	4,020	33,900	8.42 [2]	3,600	31,600	8.79
Maryland	26,100	237,000	9.08 [2]	22,300	200,000	8.95
Massachusetts	11,200	130,000	11.58 [2]	10,500	122,000	11.59
Michigan	26,100	136,000	5.20	20,400	115,000	5.66
Minnesota	10,300	122,000	11.76	8,670	110,000	12.73
Mississippi[3]	4,380 [2]	88,800 [2]	20.29 [2]	3,130	63,400	20.25
Missouri	76,400	614,000	8.04	67,700	598,000	8.83
Montana	1,980	14,000	7.05	1,990	20,400	10.25
Nebraska	7,960 [2]	78,100 [2]	9.81 [2]	6,340	59,700	9.42
Nevada	10,200	95,100	9.31 [2]	8,290	90,500	10.92
New Hampshire	5,170 [2]	50,900 [2]	9.83 [2]	4,680	47,000	10.06
New Jersey	17,900 [2]	155,000 [2]	8.66 [2]	14,500	124,000	8.51
New Mexico	7,020	43,400	6.18	6,130	40,200	6.56
New York	41,000	384,000	9.37	37,200	410,000	11.03
North Carolina	57,500 [2]	806,000 [2]	14.03 [2]	38,500	584,000	15.15
North Dakota	26 [2]	133 [2]	5.12 [2]	985	3,980	4.04
Ohio	54,100	446,000	8.25 [2]	42,700	388,000	9.08
Oklahoma	47,200	345,000	7.32 [2]	36,800	308,000	8.35
Oregon	23,500	174,000	7.40	15,800	119,000	7.52
Pennsylvania	101,000	1,140,000 [2]	11.26	83,000	975,000	11.74
Rhode Island	1,840	17,900	9.70 [2]	1,820	20,200	11.10
South Carolina	22,500 [2]	235,000 [2]	10.41 [2]	18,200	201,000	11.04
South Dakota	5,390 [2]	34,300 [2]	6.37 [2]	4,450	29,300	6.58
Tennessee	46,200 [2]	461,000 [2]	9.97 [2]	40,100	431,000	10.75
Texas	150,000	1,100,000	7.34	110,000	782,000	7.09
Utah	8,950	72,700	8.13	4,830	39,400	8.17
Vermont	5,690	47,500	8.34	5,430	54,900	10.13
Virginia	57,400	712,000	12.40	42,200	577,000	13.67
Washington	17,500	168,000	9.60	14,700	131,000	8.92
West Virginia	15,200	127,000	8.36	12,500	126,000	10.04
Wisconsin	25,900 [2]	238,000	9.16 [2]	22,900	198,000	8.63
Wyoming	12,100 [2]	57,100 [2]	4.72 [2]	16,000	75,400	4.71
Other	8,760	128,000	14.56 [2]	6,550	102,000	15.59
U.S. total or average	1,460,000	13,600,000	9.36	1,170,000	11,300,000	9.68
Territory						
American Samoa[4]	(5)	(5)	(5)	(5)	(5)	(5)
Guam	325 [2]	3,780 [2]	11.62 [2]	296	3,380	11.41
Puerto Rico	11,000	96,000	8.74	8,370	68,700	8.22
Virgin Islands	(5)	(5)	(5)	(5)	(5)	(5)
Grand total or average	1,470,000	13,700,000	9.35	1,180,000	11,400,000	9.69

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Data not revised.

[3] A significant amount of sold or used material was shipped in from other States.

[4] Includes Tutuila Island and dependencies.

[5] Withheld to avoid disclosing company proprietary data; included in "Grand total or average."

TABLE 5A

CRUSHED STONE SOLD OR USED IN THE UNITED STATES IN 2009, BY SIZE OF OPERATION[1, 2]

	U.S. total			
Size range (metric tons)	Number of operations	Percentage of total	Quantity (thousand metric tons)	Percentage of total
Less than 25,000	602	15.8	4,950	0.4
25,000 to 49,999	343	9.0	11,500	1.0
50,000 to 99,999	524	13.7	34,600	3.0
100,000 to 199,999	614	16.1	80,500	6.9
200,000 to 299,999	430	11.3	97,600	8.4
300,000 to 399,999	307	8.0	96,500	8.3
400,000 to 499,999	247	6.5	101,000	8.7
500,000 to 599,999	160	4.2	78,900	6.8
600,000 to 699,999	134	3.5	78,700	6.7
700,000 to 799,999	87	2.3	58,800	5.0
800,000 to 899,999	68	1.8	52,200	4.5
900,000 to 999,999	41	1.1	35,200	3.0
1,000,000 to 1,499,999	143	3.7	157,000	13.4
1,500,000 to 1,999,999	45	1.2	69,000	5.9
2,000,000 to 2,499,999	29	0.8	58,700	5.0
2,500,000 to 4,999,999	36	0.9	111,000	9.5
5,000,000 and more	7	0.2	40,100	3.4
Total	3,817	100.0	1,170,000	100.0

[1] Data are rounded to no more than three significant digits except "Number of operations;" may not add to totals shown.

[2] Does not include recycle plants.

TABLE 5B

CRUSHED STONE SOLD OR USED IN THE UNITED STATES IN 2009, BY REGION AND SIZE OF OPERATION[1, 2]

Size range (metric tons)	Northeast				Midwest			
	Number of operations	Percentage of total	Quantity (thousand metric tons)	Percentage of total	Number of operations	Percentage of total	Quantity (thousand metric tons)	Percentage of total
Less than 25,000	83	14.1	773	0.5	147	13.4	1,460	0.4
25,000 to 49,999	63	10.7	2,050	1.2	102	9.3	3,460	1.1
50,000 to 99,999	67	11.4	4,330	2.6	150	13.7	10,100	3.1
100,000 to 199,999	99	16.9	13,300	7.9	185	16.9	24,400	7.5
200,000 to 299,999	59	10.1	13,300	7.9	130	11.9	29,300	9.0
300,000 to 399,999	55	9.4	17,300	10.3	104	9.5	32,300	9.9
400,000 to 499,999	38	6.5	15,400	9.1	85	7.8	34,700	10.7
500,000 to 599,999	35	6.0	17,200	10.2	39	3.6	19,100	5.9
600,000 to 699,999	23	3.9	13,300	7.9	33	3.0	19,300	6.0
700,000 to 799,999	13	2.2	8,770	5.2	19	1.7	12,900	4.0
800,000 to 899,999	12	2.0	9,070	5.4	17	1.6	13,000	4.0
900,000 to 999,999	3	0.5	2,540	1.5	13	1.2	11,300	3.5
1,000,000 to 1,499,999	25	4.3	27,500	16.3	38	3.5	42,100	13.0
1,500,000 to 1,999,999	7	1.2	10,600	6.3	12	1.1	18,400	5.7
2,000,000 to 2,499,999	2	0.3	3,980	2.4	8	0.7	16,400	5.0
2,500,000 to 4,999,999	3	0.5	9,470	5.6	9	0.8	26,000	8.0
5,000,000 and more	--	--	--	--	2	0.2	10,300	3.2
Total	587	100.0	169,000	100.0	1,093	100.0	325,000	99.9

Size range (metric tons)	South				West			
	Number of operations	Percentage of total	Quantity (thousand metric tons)	Percentage of total	Number of operations	Percentage of total	Quantity (thousand metric tons)	Percentage of total
Less than 25,000	113	8.5	833	0.2	259	32.3	1,880	1.4
25,000 to 49,999	77	5.8	2,630	0.5	101	12.6	3,330	2.4
50,000 to 99,999	165	12.4	11,200	2.1	142	17.7	8,990	6.5
100,000 to 199,999	199	14.9	26,100	4.9	131	16.4	16,700	12.2
200,000 to 299,999	190	14.2	43,400	8.1	51	6.4	11,600	8.4
300,000 to 399,999	125	9.4	39,600	7.4	23	2.9	7,380	5.4
400,000 to 499,999	96	7.2	39,600	7.4	28	3.5	11,500	8.3
500,000 to 599,999	73	5.5	36,100	6.8	13	1.6	6,470	4.7
600,000 to 699,999	67	5.0	39,600	7.4	11	1.4	6,500	4.7
700,000 to 799,999	52	3.9	35,000	6.5	3	0.4	2,050	1.5
800,000 to 899,999	34	2.5	26,200	4.9	5	0.6	3,880	2.8
900,000 to 999,999	21	1.6	18,000	3.4	4	0.5	3,360	2.4
1,000,000 to 1,499,999	66	4.9	71,700	13.4	14	1.7	15,200	11.1
1,500,000 to 1,999,999	21	1.6	32,000	6.0	5	0.6	8,020	5.8
2,000,000 to 2,499,999	15	1.1	30,500	5.7	4	0.5	7,800	5.7
2,500,000 to 4,999,999	18	1.3	57,300	10.7	6	0.7	18,200	13.3
5,000,000 and more	4	0.3	25,100	4.7	1	0.1	4,610	3.4
Total	1,336	100.0	535,000	100.0	801	100.0	138,000	100.0

-- Zero.

[1] Data are rounded to no more than three significant digits except "Number of operations;" may not add to totals shown.

[2] Does not include recycle plants.

TABLE 6

LIMESTONE, DOLOMITE, CALCAREOUS MARL, AND MARBLE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY STATE[1]

(Thousand metric tons and thousand dollars)

State	Limestone		Dolomite		Calcareous marl		Marble	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	30,400 [2]	279,000 [2]	--	--	--	--	1,680	13,600
Alaska	--	--	--	--	--	--	--	-
Arizona	3,700 [2]	36,800 [2]	--	--	--	--	35	405
Arkansas	10,600	68,800	820	6,930	--	--	--	-
California	16,400 [2]	105,000 [2]	131	1,300	--	--	2,490	30,700
Colorado	507 [2]	5,400 [2]	--	--	--	--	--	-
Connecticut	1,160 [2]	23,800 [2]	--	--	--	--	--	-
Delaware	--	--	--	--	--	--	--	-
Florida	46,300 [2]	620,000 [2]	171	1,370	--	--	--	-
Georgia	5,100	59,700	--	--	--	--	1,050	31,800
Hawaii	--	--	--	--	--	--	--	-
Idaho	237	3,430	--	--	--	--	--	-
Illinois	44,700 [2]	384,000 [2]	11,100	123,000	--	--	--	-
Indiana	40,200 [2]	259,000 [2]	3,830	30,200	--	--	--	-
Iowa	32,600 [2]	297,000 [2]	--	--	--	--	--	-
Kansas	16,900	141,000	--	--	--	--	--	-
Kentucky	44,300	389,000	--	--	--	--	--	-
Louisiana	--	--	--	--	--	--	--	-
Maine	1,540	12,200	--	--	--	--	--	-
Maryland	13,100 [2]	110,000 [2]	--	--	--	--	--	-
Massachusetts	1,560 [2]	28,100 [2]	--	--	--	--	--	-
Michigan	15,700 [2]	93,400 [2]	3,860	19,900	--	--	--	-
Minnesota	2,720 [2]	33,200 [2]	1,600	22,400	--	--	--	-
Mississippi[3]	3,080	62,700	--	--	--	--	--	-
Missouri	61,800 [2]	460,000 [2]	2,350	17,100	--	--	--	-
Montana	1,570	16,600	--	--	--	--	--	-
Nebraska	6,130	58,500	--	--	--	--	--	-
Nevada	2,890 [2]	36,300 [2]	--	--	--	--	--	-
New Hampshire	--	--	--	--	--	--	--	-
New Jersey	--	--	--	--	--	--	--	-
New Mexico	3,690	21,200	--	--	--	--	--	-
New York	19,400 [2]	195,000 [2]	9,870	114,000	--	--	96	950
North Carolina	4,110 [2]	59,400 [2]	--	--	--	--	--	-
North Dakota	--	--	--	--	--	--	--	-
Ohio	40,400 [2]	368,000 [2]	1,530	11,300	--	--	--	-
Oklahoma	31,300 [2]	262,000 [2]	--	--	--	--	--	-
Oregon	--	--	--	--	--	--	--	-
Pennsylvania	46,200 [2]	479,000 [2]	10,200	98,800	--	--	--	-
Rhode Island	--	--	--	--	--	--	--	-
South Carolina	2,130	22,000	--	--	2,480	14,000	--	-
South Dakota	2,470	14,200	--	--	--	--	--	-
Tennessee	38,600 [2]	408,000 [2]	--	--	--	--	--	-
Texas	99,700 [2]	708,000 [2]	--	--	--	--	86	[illegible]
Utah	3,430 [2]	29,700 [2]	--	--	--	--	--	-
Vermont	1,800 [2]	17,700 [2]	--	--	--	--	--	-
Virginia	15,300 [2]	189,000 [2]	--	--	--	--	--	-

See footnotes at end of table.

TABLE 6—Continued
LIMESTONE, DOLOMITE, CALCAREOUS MARL, AND MARBLE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY STATE[1]

(Thousand metric tons and thousand dollars)

State	Limestone		Dolomite		Calcareous marl		Marble	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Washington	988 [2]	9,150 [2]	102	454	--	--	--	--
West Virginia	11,400	113,000	--	--	--	--	--	--
Wisconsin	19,100 [2]	119,000 [2]	117	789	--	--	--	--
Wyoming	3,420 [2]	21,800 [2]	--	--	--	--	--	--
Total	747,000	6,620,000	45,700	447,000	2,480	14,000	5,450	81,700

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes limestone-dolomite reported with no distinction between the two kinds of stone.

[3] A significant amount of sold or used material was shipped in from other States.

TABLE 7
GRANITE, TRAPROCK, SANDSTONE AND QUARTZITE, AND SLATE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY STATE[1]

(Thousand metric tons and thousand dollars)

State	Granite		Traprock		Sandstone and quartzite[2]		Slate	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	2,210	20,300	--	--	1,220	11,300	781	6,340
Alaska	290	4,270	--	--	--	--	--	--
Arizona	2,310	19,900	--	--	744	7,400	--	--
Arkansas	6,040	46,300	--	--	11,000	84,400	--	--
California	9,780	101,000	4,540	48,900	1,120	11,500	102	1,180
Colorado	4,560	33,800	--	--	1,040	8,570	--	--
Connecticut	459	4,900	5,110	56,300	--	--	--	--
Delaware	--	--	--	--	--	--	--	--
Florida	--	--	--	--	--	--	--	--
Georgia	38,100	417,000	--	--	--	--	--	--
Hawaii	--	--	5,180	88,000	--	--	--	--
Idaho	283	1,390	1,710	8,660	--	--	--	--
Illinois	--	--	--	--	653	5,930	--	--
Indiana	--	--	--	--	--	--	--	--
Iowa	--	--	--	--	--	--	--	--
Kansas	--	--	--	--	--	--	--	--
Kentucky	--	--	--	--	--	--	--	--
Louisiana	--	--	--	--	--	--	--	--
Maine	1,260	12,000	--	--	404	3,610	--	--
Maryland	5,160	45,500	3,250	35,900	93	1,290	--	--
Massachusetts	3,240	34,000	4,510	46,700	--	--	--	--
Michigan	--	--	--	--	--	--	--	--
Minnesota	2,640	32,400	--	--	1,570	21,000	--	--
Mississippi	--	--	--	--	--	--	--	--

See footnotes at end of table.

TABLE 7—Continued
GRANITE, TRAPROCK, SANDSTONE AND QUARTZITE, AND SLATE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY STATE[1]

(Thousand metric tons and thousand dollars)

State	Granite		Traprock		Sandstone and quartzite[2]		Slate	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Missouri	1,200	101,000	2,160	15,800	--	--	--	-
Montana	--	--	--	--	--	--	--	-
Nebraska	--	--	--	--	--	--	--	-
Nevada	189	1,430	--	--	670	7,380	--	-
New Hampshire	2,720	27,000	1,600	16,700	181	1,820	--	-
New Jersey	5,770	51,000	8,660	71,800	--	--	--	-
New Mexico	--	--	--	--	208	1,630	--	-
New York	1,110	13,300	2,840	45,200	2,190	24,400	167	1,64
North Carolina	28,300	432,000	4,290	66,300	--	--	--	-
North Dakota	--	--	--	--	655	2,310	--	-
Ohio	--	--	--	--	426	3,870	--	-
Oklahoma	2,810	24,400	--	--	861	7,350	--	-
Oregon	564	4,500	6,930	55,500	--	--	--	-
Pennsylvania	2,780	28,700	5,190	185,000	11,300	113,000	888	10,0
Rhode Island	--	--	--	--	--	--	--	-
South Carolina	13,100	159,000	--	--	--	--	--	-
South Dakota	--	--	--	-	1,970	15,000	--	-
Tennessee	--	--	--	--	1,070	18,100	--	-
Texas	--	--	--	--	2,480	9,870	--	-
Utah	--	--	--	--	239	2,940	--	-
Vermont	--	--	--	--	897	10,900	237	2,3
Virginia	17,400	258,000	7,130	99,400	1,070	15,200	202	1,2
Washington	885	8,630	5,810	49,000	717	13,000	--	-
West Virginia	--	--	--	--	1,130	12,300	--	-
Wisconsin	1,780	7,880	1,420	67,400	--	--	--	-
Wyoming	--	--	--	--	--	--	--	-
Total	155,000	1,890,000	70,300	957,000	43,900	414,000	2,380	22,9

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes sandstone-quartzite reported with no distinction between the two kinds of stone.

TABLE 8
SHELL, VOLCANIC CINDER AND SCORIA, AND MISCELLANEOUS STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY STATE[1]

(Thousand metric tons and thousand dollars)

State	Shell		Volcanic cinder and scoria		Miscellaneous stone	
	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	--	--	--	--	84	844
Alaska	--	--	--	--	1,650	30,600
Arizona	--	--	99	794	2,230	14,800
Arkansas	--	--	--	--	1,560	10,700
California	--	--	333	4,360	6,460	72,900
Colorado	--	--	--	--	862	15,400

See footnotes at end of table.

TABLE 8—Continued
SHELL, VOLCANIC CINDER AND SCORIA, AND MISCELLANEOUS STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY STATE[1]

(Thousand metric tons and thousand dollars)

State	Shell		Volcanic cinder and scoria		Miscellaneous stone	
	Quantity	Value	Quantity	Value	Quantity	Value
Connecticut	--	--	--	--	1,310	15,500
Delaware[2]	--	--	--	--	W	W
Florida	414	5,310	--	--	1,670	16,000
Georgia	--	--	--	--	855	9,060
Hawaii	--	--	121	1,540	623	11,500
Idaho	--	--	--	--	2,180	17,400
Illinois	--	--	--	--	42	245
Indiana	--	--	--	--	89	550
Iowa	--	--	--	--	37	270
Kansas	--	--	--	--	291	2,570
Kentucky	--	--	--	--	--	--
Louisiana[2]	--	--	--	--	W	W
Maine	--	--	--	--	392	3,800
Maryland	--	--	--	--	784	6,930
Massachusetts	--	--	--	--	1,230	13,300
Michigan	--	--	--	--	791	1,960
Minnesota	--	--	--	--	131	1,330
Mississippi[2]	--	--	--	--	45	664
Missouri	--	--	--	--	259	3,830
Montana	--	--	--	--	417	3,800
Nebraska	--	--	--	--	204	1,230
Nevada	--	--	149	1,440	4,390	44,000
New Hampshire	--	--	--	--	183	1,580
New Jersey	--	--	--	--	107	908
New Mexico	--	--	290	2,640	1,940	14,800
New York	--	--	--	--	1,520	15,900
North Carolina	--	--	--	--	1,810	26,300
North Dakota	--	--	294	1,490	36	183
Ohio	--	--	--	--	326	4,060
Oklahoma	--	--	--	--	1,840	14,200
Oregon	--	--	4	30	8,310	58,900
Pennsylvania	--	--	--	--	6,460	59,900
Rhode Island	--	--	--	--	1,820	20,200
South Carolina	--	--	--	--	418	5,520
South Dakota	--	--	--	--	3	20
Tennessee	--	--	--	--	454	4,920
Texas	--	--	--	--	7,940	59,200
Utah	--	--	--	--	1,160	6,770
Vermont	--	--	--	--	2,500	24,000
Virginia	--	--	--	--	1,050	14,200
Washington	--	--	--	--	6,220	51,100
West Virginia	--	--	--	--	36	321
Wisconsin	--	--	--	--	466	2,640
Wyoming	--	--	6,880	34,400	5,710	19,300
Other	--	--	--	--	6,550	102,000
Total	414	5,310	8,170	46,700	85,400	806,000

W Withheld to avoid disclosing company proprietary data; included with "Other." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] A significant amount of sold or used material was shipped in from other States.

TABLE 9

CRUSHED STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY USE[1]

Use	Quantity (thousand metric tons)	Value (thousands)	Unit value
Construction:			
Coarse aggregate (+1½ inch):			
Macadam	1,650	$17,900	$10.83
Riprap and jetty stone	9,580	99,900	10.42
Filter stone	3,590	36,600	10.21
Other coarse aggregate	17,400	195,000	11.22
Coarse aggregate, graded:			
Concrete aggregate, coarse	29,800	292,000	9.82
Bituminous aggregate, coarse	19,100	188,000	9.80
Bituminous surface-treatment aggregate	6,490	80,300	12.38
Railroad ballast	9,540	88,700	9.30
Other graded coarse aggregate	94,700	1,130,000	11.89
Fine aggregate (- ⅜ inch):			
Stone sand, concrete	4,530	54,300	11.99
Stone sand, bituminous mix or seal	6,240	62,400	10.01
Screening, undesignated	9,420	85,800	9.11
Other fine aggregate	44,300	514,000	11.62
Coarse and fine aggregates:			
Graded road base or subbase	56,000	420,000	7.50
Unpaved road surfacing	12,200	91,900	7.56
Terrazzo and exposed aggregate	328	8,040	24.52
Crusher run or fill or waste	14,900	112,000	7.49
Roofing granules	2,590	313,000	121.27
Other coarse and fine aggregates	75,900	728,000	9.60
Other construction materials	6,540	50,200	7.67
Agricultural:			
Agricultural limestone	7,810	74,500	9.53
Poultry grit and mineral food	970	19,900	20.56
Other agricultural uses	585	21,800	37.31
Chemical and metallurgical:			
Cement manufacture	52,900	276,000	5.21
Lime manufacture	11,700	101,000	8.60
Dead-burned dolomite manufacture	--	--	--
Flux stone	2,490	15,300	6.14
Chemical stone	W	W	W
Glass manufacture	896	22,000	24.59
Sulfur oxide removal	5,690	45,800	8.05
Special:			
Mine dusting or acid water treatment	149	7,080	47.53
Asphalt fillers or extenders	687	8,320	12.10
Whiting or whiting substitute	W	W	W
Other fillers or extenders	2,220	35,500	15.99
Other miscellaneous uses and specified uses not listed	2,220	42,700	19.27
Unspecified:[2]			
Reported	307,000	3,050,000	9.93
Estimated	346,000	3,020,000	8.74
Total or average	1,170,000	11,300,000	9.70

See footnotes at end of table.

TABLE 9—Continued

CRUSHED STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY USE[1]

W Withheld to avoid disclosing company proprietary data; included in "Total or average." -- Zero.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Reported and estimated production without a breakdown by end use.

TABLE 10

LIMESTONE AND DOLOMITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY USE[1]

(Thousand metric tons and thousand dollars)

Use	Limestone[2]		Dolomite	
	Quantity	Value	Quantity	Value
Construction:				
Coarse aggregate (+1½ inch):				
Macadam	1,200	13,300	16	139
Riprap and jetty stone	6,960	70,500	204	2,250
Filter stone	2,260	20,600	107	1,010
Other coarse aggregate	12,300	120,000	1,070	12,000
Coarse aggregate, graded:				
Concrete aggregate, coarse	19,100	187,000	3,020	22,100
Bituminous aggregate, coarse	10,200	94,900	1,360	13,300
Bituminous surface-treatment aggregate	3,340	36,000	853	8,560
Railroad ballast	2,120	17,900	95	777
Other graded coarse aggregate	64,600	691,000	5,110	60,800
Fine aggregate (- ⅜ inch):				
Stone sand, concrete	2,400	24,300	84	711
Stone sand, bituminous mix or seal	2,740	26,100	703	7,210
Screening, undesignated	5,560	50,300	313	2,380
Other fine aggregate	23,600	261,000	3,460	41,600
Coarse and fine aggregates:				
Graded road base or subbase	39,200	284,000	1,830	13,800
Unpaved road surfacing	8,370	66,800	817	6,340
Terrazzo and exposed aggregate	82	1,450	--	--
Crusher run or fill or waste	8,350	52,400	1,330	10,800
Roofing granules	325	3,960	--	--
Other coarse and fine aggregates	44,400	397,000	2,570	20,700
Other construction materials	2,550	23,400	30	185
Agricultural:				
Agricultural limestone	7,050	67,300	732	6,930
Poultry grit and mineral food	814	10,300	--	--
Other agricultural uses	285	18,000	--	--
Chemical and metallurgical:				
Cement manufacture	48,900	259,000	--	--
Lime manufacture	11,600	100,000	--	--
Dead-burned dolomite manufacture	--	--	--	--
Flux stone	738	6,440	1,670	7,350
Chemical stone	227	2,040	--	--
Glass manufacture	63	1,260	--	--
Sulfur oxide removal	5,560	43,300	--	--

See footnotes at end of table.

TABLE 10—Continued

LIMESTONE AND DOLOMITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY USE[1]

(Thousand metric tons and thousand dollars)

Use	Limestone[2]		Dolomite	
	Quantity	Value	Quantity	Value
Special:				
Mine dusting or acid water treatment	120	5,970	--	--
Asphalt fillers or extenders	404	5,550	--	--
Whiting or whiting substitute	100	2,600	--	--
Other fillers or extenders	1,440	13,900	60	571
Other miscellaneous uses and specified uses not listed	186	2,540	63	340
Unspecified:[3]				
Reported	167,000	1,610,000	14,200	158,000
Estimated	242,000	2,030,000	5,990	48,900
Total	747,000	6,620,000	45,700	447,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes a minor amount of limestone-dolomite reported without a distinction between the two.

[3] Reported and estimated production without a breakdown by end use.

TABLE 11

LIMESTONE AND DOLOMITE SOLD OR USED BY PRODUCERS IN 2009, BY STATE AND USE[1]

(Thousand metric tons and thousand dollars)

State	Concrete aggregate		Bituminous aggregate		Roadstone and coverings		Riprap and railroad ballast		Other construction uses	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	1,770	15,700	5,440	52,200	2,970	28,100	492	4,760	6,010	67,800
Alaska	--	--	--	--	--	--	--	--	--	--
Arizona	3	48	--	--	3	31	--	--	--	--
Arkansas	545	4,210	444	4,040	2,050	13,400	144	1,100	1,970	12,800
California	W	W	W	W	W	W	W	W	911	7,960
Colorado	--	--	W	W	W	W	W	W	W	W
Connecticut	10	135	29	392	41	331	W	W	W	W
Delaware	--	--	--	--	--	--	--	--	--	--
Florida	4,180	76,200	4,430	109,000	3,440	26,700	55	838	3,510	39,400
Georgia	W	W	W	W	W	W	--	--	940	9,980
Hawaii	--	--	--	--	--	--	--	--	--	--
Idaho	--	--	--	--	23	101	--	--	--	--
Illinois	5,920	56,300	9,170	82,800	5,300	40,400	387	4,260	2,950	22,600
Indiana	5,060	34,100	6,930	50,100	5,280	33,000	W	W	1,060	6,490
Iowa	1,160	13,900	705	9,070	6,790	65,300	366	6,710	1,200	11,100
Kansas	368	3,570	945	9,270	1,440	9,400	49	576	1,140	8,330
Kentucky	2,380	21,100	7,590	72,500	3,000	24,900	1,100	11,900	4,290	37,000
Louisiana	--	--	--	--	--	--	--	--	--	--
Maine	19	58	25	130	W	W	--	--	--	--
Maryland	770	6,410	1,950	18,800	297	2,630	14	203	844	6,510
Massachusetts	--	--	--	--	--	--	--	--	--	--

See footnotes at end of table.

TABLE 11—Continued
LIMESTONE AND DOLOMITE SOLD OR USED BY PRODUCERS IN 2009, BY STATE AND USE[1]

(Thousand metric tons and thousand dollars)

State	Concrete aggregate		Bituminous aggregate		Roadstone and coverings		Riprap and railroad ballas		Other construction uses	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Michigan	2,820	22,800	1,080	6,950	1,880	13,300	119	1,750	778	5,560
Minnesota	W	W	W	W	444	5,100	W	W	W	W
Mississippi[2]	W	W	W	W	W	W	W	W	W	W
Missouri	2,170	19,700	930	7,330	6,070	40,400	2,070	16,500	1,490	9,250
Montana	--	--	--	--	W	W	W	W	W	W
Nebraska	W	W	W	W	W	W	W	W	W	W
Nevada	--	--	--	--	--	--	--	--	--	--
New Hampshire	--	--	--	--	--	--	--	--	--	--
New Jersey	--	--	--	--	--	--	--	--	--	--
New Mexico	185	2,090	696	3,320	61	798	11	232	32	253
New York	3,840	46,500	4,680	54,300	1,620	19,900	168	1,880	3,420	32,200
North Carolina	W	W	W	W	W	W	W	W	W	W
North Dakota	--	--	--	--	--	--	--	--	--	--
Ohio	1,070	9,110	6,240	54,000	1,960	14,400	40	429	2,050	15,600
Oklahoma	3,060	38,400	3,480	28,100	771	6,410	149	1,920	1,480	11,000
Oregon	--	--	--	--	--	--	--	--	--	--
Pennsylvania	3,760	37,800	7,500	72,900	4,220	39,400	764	8,590	5,210	42,600
Rhode Island	--	--	--	--	--	--	--	--	--	--
South Carolina	W	W	W	W	W	W	--	--	W	W
South Dakota	--	--	--	--	--	--	--	--	--	--
Tennessee	2,510	34,300	8,480	104,000	2,490	24,000	525	5,370	8,410	81,700
Texas	6,440	49,200	10,800	116,000	8,850	50,100	967	9,070	12,800	80,100
Utah	--	--	--	--	3	12	W	W	45	307
Vermont	W	W	W	W	73	430	W	W	215	1,500
Virginia	1,310	15,400	1,780	19,000	1,080	10,400	228	2,870	2,730	24,400
Washington	--	--	W	W	W	W	--	--	--	--
West Virginia	293	2,850	2,230	19,000	1,100	20,800	52	546	405	3,130
Wisconsin	426	2,820	1,220	6,530	2,220	10,300	494	1,390	2,470	11,600
Wyoming	W	W	W	W	W	W	--	--	--	--
Total	50,100	513,000	86,800	900,000	63,500	500,000	8,190	80,900	66,300	549,000
Total withheld	1,690	24,200	2,580	43,700	1,200	14,800	1,180	10,600	1,620	35,400
Grand total	51,700	537,000	89,300	944,000	64,700	515,000	9,370	91,500	67,900	585,000

	Cement manufacture		Agricultural uses		Lime manufacture		Other uses		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	1,540	9,790	W	W	W	W	10,100	81,400	30,400[3]	279,000
Alaska	--	--	--	--	--	--	--	--	--	--
Arizona	1,580	16,300	W	W	W	W	2,080	19,700	3,700[3]	36,800
Arkansas	W	W	W	W	--	--	4,850	36,700	11,400	75,700
California	8,930	30,400	W	W	--	--	5,810	55,800	16,600[3]	107,000
Colorado	--	--	--	--	--	--	441	4,710	507[3]	5,400
Connecticut	--	--	7	55	--	--	W	W	1,160[3]	23,800
Delaware	--	--	--	--	--	--	--	--	--	--
Florida	W	W	W	W	--	--	30,300	365,000	46,500[3]	622,000
Georgia	--	--	W	W	--	--	3,010	35,500	5,100	59,700
Hawaii	--	--	--	--	--	--	--	--	--	--

See footnotes at end of table.

TABLE 11—Continued
LIMESTONE AND DOLOMITE SOLD OR USED BY PRODUCERS IN 2009, BY STATE AND USE[1]

(Thousand metric tons and thousand dollars)

State	Cement manufacture		Agricultural uses		Lime manufacture		Other uses		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Idaho	--	--	W	W	--	--	W	W	237	3,430
Illinois	W	W	W	W	--	--	28,800	275,000	55,800 [3]	507,000
Indiana	W	W	1,370	7,560	12	60	21,900	146,000	44,000 [3]	290,000
Iowa	2,050	4,300	W	W	W	W	19,400	180,000	32,600 [3]	297,000
Kansas	W	W	W	W	--	--	12,100	103,000	16,900	141,000
Kentucky	W	W	354	2,240	W	W	20,500	175,000	44,300	389,000
Louisiana	--	--	--	--	--	--	--	--	--	--
Maine	W	W	--	--	--	--	1,070	9,590	1,540	12,200
Maryland	W	W	W	W	--	--	9,130	75,700	13,100 [3]	110,000
Massachusetts	--	--	--	--	--	--	1,560	28,100	1,560 [3]	28,100
Michigan	2,320	4,210	120	781	--	--	10,500	58,000	19,600 [3]	113,000
Minnesota	--	--	112	1,120	--	--	2,330	27,800	4,320 [3]	55,600
Mississippi[2]	--	--	W	W	--	--	986	17,400	3,080	62,700
Missouri	W	W	548	2,750	W	W	45,600	354,000	64,100 [3]	477,000
Montana	574	7,910	W	W	W	W	W	W	1,570	16,600
Nebraska	W	W	673	8,590	--	--	4,150	38,600	6,130	58,500
Nevada	W	W	W	W	W	W	1,430	14,600	2,890	36,300
New Hampshire	--	--	--	--	--	--	--	--	--	--
New Jersey	--	--	--	--	--	--	--	--	--	--
New Mexico	--	--	--	--	--	--	2,700	14,500	3,690	21,200
New York	W	W	101	1,140	W	W	14,800	146,000	29,200 [3]	309,000
North Carolina	--	--	W	W	--	--	3,970	56,900	4,110 [3]	59,400
North Dakota	--	--	--	--	--	--	--	--	--	--
Ohio	--	--	305	2,560	--	--	30,300	284,000	41,900 [3]	380,000
Oklahoma	W	W	W	W	--	--	21,300	171,000	31,300 [3]	262,000
Oregon	--	--	--	--	--	--	--	--	--	--
Pennsylvania	1,870	24,900	W	W	W	W	31,600	331,000	56,400 [3]	578,000
Rhode Island	--	--	--	--	--	--	--	--	--	--
South Carolina	--	--	56	500	--	--	1,730	18,400	2,130	22,000
South Dakota	625	1,810	--	--	--	--	1,850	12,400	2,470	14,200
Tennessee	W	W	W	W	--	--	15,500	154,000	38,600 [3]	408,000
Texas	11,600	50,300	W	W	W	W	47,800	351,000	99,700 [3]	708,000
Utah	1,650	14,400	W	W	W	W	1,240	10,600	3,430 [3]	29,700
Vermont	--	--	W	W	--	--	1,440	15,200	1,800 [3]	17,700
Virginia	--	--	W	W	W	W	6,790	90,300	15,300 [3]	189,000
Washington	W	W	W	W	W	W	355	4,220	1,090 [3]	9,600
West Virginia	W	W	W	W	--	--	6,710	61,700	11,400	113,000
Wisconsin	--	--	411	4,320	--	--	12,000	82,800	19,200 [3]	120,000
Wyoming	677	4,190	--	--	--	--	2,730	17,500	3,420 [3]	21,800
Total	33,400	169,000	4,050	31,600	12	60	439,000	3,920,000	XX	XX
Total withheld	15,600	90,500	4,920	72,400	11,600	99,900	1,000	10,600	XX	XX
Grand total	49,000	259,000	8,970	104,000	11,600	100,000	440,000	3,930,000	792,000	7,070,000

W Withheld to avoid disclosing company proprietary data; included in "Total" or "Total withheld." XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] A significant amount of sold or used material was shipped in from other States.

[3] Includes limestone-dolomite reported with no distinction between the two kinds of stone.

TABLE 12

GRANITE, TRAPROCK, SANDSTONE AND QUARTZITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY USE[1]

(Thousand metric tons and thousand dollars)

Use	Granite		Traprock		Sandstone and quartzite[2]	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction:						
Coarse aggregate (+1½ inch):						
Macadam	158	1,760	164	1,290	100	1,190
Riprap and jetty stone	600	7,690	267	4,190	1,290	11,100
Filter stone	635	8,270	317	3,580	150	1,490
Other coarse aggregate	1,830	31,300	1,070	19,500	289	2,860
Coarse aggregate, graded:						
Concrete aggregate, coarse	3,610	40,200	1,390	15,900	901	8,320
Bituminous aggregate, coarse	3,020	27,200	2,180	19,400	906	9,650
Bituminous surface-treatment aggregate	982	15,700	473	4,400	367	5,290
Railroad ballast	4,090	40,400	1,020	9,520	164	1,760
Other graded coarse aggregate	17,200	260,000	4,480	66,400	944	11,200
Fine aggregate (- ⅜ inch):						
Stone sand, concrete	391	4,160	254	6,500	640	7,490
Stone sand, bituminous mix or seal	1,030	10,000	682	7,100	477	5,250
Screening, undesignated	2,050	21,400	608	4,740	459	3,190
Other fine aggregate	11,800	143,000	3,390	46,500	1,060	12,700
Coarse and fine aggregates:						
Graded road base or subbase	4,250	42,000	3,900	28,400	2,330	19,200
Unpaved road surfacing	370	4,210	686	4,490	680	4,180
Terrazzo and exposed aggregate	133	2,530	--	--	7	90
Crusher run or fill or waste	1,840	19,100	919	8,000	680	5,930
Roofing granules	--	--	--	--	6	183
Other coarse and fine aggregates	17,600	191,000	5,490	51,100	1,060	8,770
Other construction materials	38	333	8	65	2,160	9,560
Agricultural:						
Agricultural limestone	--	--	--	--	--	--
Poultry grit and mineral food	--	--	--	--	--	--
Other agricultural uses	--	--	--	--	--	--
Chemical and metallurgical:						
Cement manufacture	--	--	--	--	457	2,710
Lime manufacture	--	--	--	--	--	--
Dead-burned dolomite manufacture	--	--	--	--	--	--
Flux stone	--	--	--	--	83	1,490
Chemical stone	--	--	--	--	--	--
Glass manufacture	--	--	--	--	833	20,800
Sulfur oxide removal	--	--	--	--	--	--
Special:						
Mine dusting or acid water treatment	--	--	--	--	--	--
Asphalt fillers or extenders	--	--	--	--	--	--
Whiting or whiting substitute	--	--	--	--	--	--
Other fillers or extenders	--	--	--	--	--	--
Other miscellaneous uses and specified uses not listed	1,120	102,000	1,560	211,000	1,330	18,700

See footnotes at end of table.

TABLE 12—Continued

GRANITE, TRAPROCK, SANDSTONE AND QUARTZITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY USE[1]

(Thousand metric tons and thousand dollars)

Use	Granite		Traprock		Sandstone and quartzite[2]	
	Quantity	Value	Quantity	Value	Quantity	Value
Unspecified:[3]						
Reported	58,100	676,000	22,600	251,000	8,400	73,000
Estimated	24,200	242,000	18,900	194,000	18,100	168,000
Total	155,000	1,890,000	70,300	957,000	43,900	414,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes sandstone-quartzite reported with no distinction between the two kinds of stone.

[3] Reported and estimated production without a breakdown by end use.

TABLE 13

MARBLE, VOLCANIC CINDER AND SCORIA, AND MISCELLANEOUS STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY USE[1]

(Thousand metric tons and thousand dollars)

Use	Marble		Volcanic cinder and scoria		Miscellaneous stone	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction:						
Coarse aggregate (+1½ inch):						
Macadam	--	--	--	--	16	227
Riprap and jetty stone	--	--	4	67	251	4,070
Filter stone	--	--	--	--	112	1,600
Other coarse aggregate	--	--	10	111	936	10,700
Coarse aggregate, graded:						
Concrete aggregate, coarse	--	--	--	--	1,650	18,400
Bituminous aggregate, coarse	--	--	--	--	1,410	22,700
Bituminous surface-treatment aggregate	--	--	--	--	456	10,100
Railroad ballast	--	--	--	--	2,050	18,300
Other graded coarse aggregate	--	--	96	842	2,230	34,200
Fine aggregate (- ⅜ inch):						
Stone sand, concrete	--	--	--	--	711	10,700
Stone sand, bituminous mix or seal	--	--	--	--	601	6,750
Screening, undesignated	--	--	--	--	436	3,650
Other fine aggregate	--	--	37	482	829	8,250
Coarse and fine aggregates:						
Graded road base or subbase	--	--	--	--	4,300	31,600
Unpaved road surfacing	--	--	--	--	1,010	4,070
Terrazzo and exposed aggregate	25	3,250	20	250	57	454
Crusher run or fill or waste	--	--	26	269	1,370	12,300
Roofing granules	--	--	--	--	-	-
Other coarse and fine aggregates	--	--	118	1,540	4,540	57,500
Other construction materials	149	1,940	137	984	1,820	14,700
Agricultural:						
Agricultural limestone	--	--	--	--	2	11
Poultry grit and mineral food	--	--	--	--	25	2,860
Other agricultural uses	189	7,080	--	--	99	939

See footnotes at end of table.

TABLE 13—Continued

MARBLE, VOLCANIC CINDER AND SCORIA, AND MISCELLANEOUS STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2009, BY USE[1]

(Thousand metric tons and thousand dollars)

Use	Marble		Volcanic cinder and scoria		Miscellaneous stone	
	Quantity	Value	Quantity	Value	Quantity	Value
Chemical and metallurgical:						
Cement manufacture	--	--	--	--	1,070	4,520
Lime manufacture	--	--	--	--	--	--
Dead-burned dolomite manufacture	--	--	--	--	--	--
Flux stone	--	--	--	--	--	--
Chemical stone	--	--	--	--	--	--
Glass manufacture	--	--	--	--	--	--
Sulfur oxide removal	--	--	--	--	128	2,520
Special:						
Mine dusting or acid water treatment	--	--	--	--	--	--
Asphalt fillers or extenders	--	--	--	--	--	--
Whiting or whiting substitute	--	--	--	--	73	364
Other fillers or extenders	--	--	--	--	73	454
Other miscellaneous uses and specified uses not listed	2,910	44,600	96	945	341	4,650
Unspecified:[2]						
Reported	--	--	6,970	34,800	29,300	245,000
Estimated	2,170	24,900	653	6,390	29,600	274,000
Total	5,450	81,700	8,170	46,700	85,400	806,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Reported and estimated production without a breakdown by end use.

TABLE 14

RECYCLED ASPHALT SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

State	2008			2009		
	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value
Alabama	112	$2,090	$18.62	126	$2,520	$20.02
Alaska	105 r	1,770 r	16.81 r	57	1,200	21.02
Arizona	137	820	5.99	227	1,370	6.02
Arkansas	--	--	--	85	908	10.68
California	1,550 r	12,500 r	8.11 r	1,700	11,600	6.82
Colorado	514 r	4,950	9.62 r	362	4,050	11.18
Connecticut	133	530	3.98	124	517	4.17
Delaware	2	35	17.50	2	35	17.50
Florida	415	5,980	14.40 r	903	12,300	13.66
Georgia	96	2,770	28.89	196	4,280	21.83
Hawaii	73	1,040	14.25	73	1,030	14.16
Idaho	88	659	7.49	94	587	6.24

See footnotes at end of table.

TABLE 14—Continued

RECYCLED ASPHALT SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

	2008			2009		
State	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value
Illinois	843	8,210	9.74	1,460	12,500	8.57
Indiana	172 r	1,640 r	9.54 r	225	1,870	8.30
Iowa	37	290	7.84	26	209	8.04
Kansas	1,140	30,900	27.02 r	1,290	33,200	25.74
Kentucky	49	928	18.94	49	928	18.94
Louisiana	147	908	6.18	134	757	5.65
Maine	176	1,380	7.82	139	1,130	8.14
Maryland	194	999	5.15	145	702	4.84
Massachusetts	305	1,960	6.42	287	2,410	8.40
Michigan	315	1,540	4.88	532	3,010	5.67
Minnesota	805 r	7,240 r	8.99 r	528	5,430	10.29
Mississippi	81	1,570	19.35	136	1,780	13.09
Missouri	208	922	4.43	164	693	4.23
Montana	75	338	4.51	8	89	11.13
Nebraska	32	745	23.28	83	1,090	13.14
Nevada	49	275	5.61	275	1,500	5.46
New Hampshire	256	3,420	13.34	296	3,480	11.74
New Jersey	154	1,120	7.24	155	1,350	8.70
New Mexico	195	1,410	7.25	771	9,850	12.78
New York	256	1,630	6.36	380	2,840	7.47
North Carolina	318	2,300	7.23	874	7,850	8.98
North Dakota	28	126	4.50	40	450	11.25
Ohio	68	249	3.66	179	1,090	6.10
Oklahoma	103	1,540	14.98	118	1,570	13.33
Oregon	235 r	1,940 r	8.26 r	216	1,580	7.29
Pennsylvania	1,120	10,700	9.54	1,020	10,100	9.97
Rhode Island	69	920	13.33	66	202	3.06
South Carolina	191 r	4,010 r	21.02 r	204	4,420	21.65
South Dakota	80	446	5.58	120	751	6.26
Tennessee	54	409	7.57	197	1,450	7.36
Texas	700	7,280	10.40	616	4,650	7.54
Utah	431 r	2,440 r	5.66 r	234	1,560	6.67
Vermont	30	242	8.07	28	425	15.18
Virginia	955	1,310 r	1.37 r	233	2,980	12.79
Washington	195	1,080	5.53	168	499	2.97
West Virginia	--	--	--	--	--	--
Wisconsin	747	4,980	6.67	624	4,290	6.87
Wyoming	29	360	12.41	14	205	14.64
U.S. total or average	14,100 r	141,000 r	9.99 r	16,000	169,000	10.60
Territory						
Puerto Rico	45	169	3.75	45	169	3.75
Grand total or average	14,100 r	141,000 r	9.97 r	16,000	170,000	10.58

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

TABLE 15

RECYCLED CONCRETE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

State	2008 Quantity (thousand metric tons)	2008 Value (thousands)	2008 Unit value	2009 Quantity (thousand metric tons)	2009 Value (thousands)	2009 Unit value
Alabama	45	$317	$7.04	51	$377	$7.39
Alaska	64 [r]	304 [r]	4.75 [r]	25	124	4.96
Arizona	192	1,050	5.48	70	485	6.93
Arkansas	--	--	--	42	193	4.60
California	2,270 [r]	17,000 [r]	7.51 [r]	1,770	14,300	8.07
Colorado	767	5,010	6.53	644	4,500	6.99
Connecticut	90	310	3.44	41	328	8.00
Delaware	7	75	10.71	7	75	10.71
Florida	233	3,640	15.63	424	4,830	11.40
Georgia	10	57	5.70	83	274	3.30
Hawaii	23	252	10.96	22	215	9.77
Idaho	27	190	7.04	32	192	6.00
Illinois	1,410	10,600	7.55	1,180	8,820	7.51
Indiana	105	717	6.83	139	752	5.41
Iowa	34	248	7.29	28	238	8.50
Kansas	25	311	12.44	297	2,230	7.51
Kentucky	440	4,370	9.93	441	4,370	9.92
Louisiana	29	434	14.97	7	71	10.14
Maine	28	163	5.82	39	294	7.54
Maryland	254	1,160	4.55	389	2,030	5.21
Massachusetts	300	2,260	7.55	192	1,610	8.39
Michigan	520	2,520	4.85	1,010	7,180	7.13
Minnesota	1,290	6,850	5.30	765	4,700	6.14
Mississippi	71	1,540	21.75	71	1,550	21.82
Missouri	1	2	2.00	1	2	2.00
Montana	81	378	4.67	20	155	7.75
Nebraska	98	877	8.95	122	1,120	9.19
Nevada	151	804	5.32	93	560	6.02
New Hampshire	11	93	8.45	12	109	9.08
New Jersey	381	2,740	7.19	583	4,730	8.11
New Mexico	171	1,840	10.74	1	2	2.00
New York	399 [r]	2,850 [r]	7.15 [r]	338	2,620	7.75
North Carolina	139	1,810	13.03	143	1,850	12.94
North Dakota	9	61	6.78	17	187	11.00
Ohio	225	1,590	7.05	337	2,230	6.61
Oklahoma	225	2,940	13.08	224	2,940	13.13
Oregon	80	747	9.34	101	882	8.73
Pennsylvania	429	2,350	5.48	420	2,450	5.82
Rhode Island	32	301	9.41	127	176	1.39
South Carolina	235	3,400	14.46	216	3,630	16.81
South Dakota	158	699	4.42	109	534	4.90
Tennessee	--	--	--	25	149	5.96
Texas	1,660	12,400	7.49	859	6,750	7.86
Utah	381 [r]	3,060 [r]	8.04 [r]	223	1,890	8.48

See footnotes at end of table.

TABLE 15—Continued

RECYCLED CONCRETE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

State	2008 Quantity (thousand metric tons)	2008 Value (thousands)	2008 Unit value	2009 Quantity (thousand metric tons)	2009 Value (thousands)	2009 Unit value
Vermont	16	81	5.06	22	102	4.64
Virginia	588	5,440	9.25	631	5,680	9.01
Washington	407	2,220	5.46	216	1,330	6.14
West Virginia	--	--	--	--	--	--
Wisconsin	645	3,580	5.55	369	1,940	5.24
Wyoming	236	1,640	6.95	59	339	5.75
U.S. total or average	15,000 r	112,000 r	7.47 r	13,000	102,000	7.83
Territory						
Puerto Rico	--	--	--	--	--	--
Grand total or average	15,000 r	112,000 r	7.45 r	13,000	102,000	7.83

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

TABLE 16

CRUSHED AND BROKEN STONE OPERATIONS IN THE UNITED STATES IN 2009, BY STATE[1]

State	Active operations	Active quarries	Dredging operations	Processing plants: Stationary	Processing plants: Portable	Processing plants: Stationary and portable	Processing plants: None or unspecified	Sales yards
Alabama	84	74	--	61	9	3	1	10
Alaska	28	28	--	6	16	2	2	2
Arizona	70	70	--	31	28	5	--	6
Arkansas	89	91	--	40	36	7	3	3
California	164	151	1	85	37	12	4	25
Colorado	47	49	--	15	19	1	5	7
Connecticut	39	38	--	21	15	2	--	1
Delaware	6	--	--	--	--	--	--	6
Florida	118	97	3	43	40	6	2	24
Georgia	93	83	--	72	6	1	3	11
Hawaii	30	30	--	11	17	1	--	1
Idaho	46	76	--	10	28	1	7	--
Illinois	161	140	--	80	50	7	2	22
Indiana	102	95	--	84	3	3	4	8
Iowa	183	216	1	29	146	2	3	2
Kansas	86	100	--	24	50	6	1	5
Kentucky	90	88	--	69	10	9	--	2
Louisiana	24	4	--	2	1	1	--	20
Maine	27	23	--	14	6	3	--	4
Maryland	42	29	--	22	4	1	1	14
Massachusetts	43	42	--	29	8	4	--	2
Michigan	42	42	--	22	7	1	1	11
Minnesota	53	60	--	12	29	1	3	8
Mississippi	24	6	--	4	1	1	--	18
Missouri	225	230	--	129	76	13	4	3
Montana	25	42	--	8	17	--	--	--
Nebraska	17	13	2	7	3	1	--	4
Nevada	29	30	--	19	8	--	1	1

See footnotes at end of table.

TABLE 16—Continued

CRUSHED AND BROKEN STONE OPERATIONS IN THE UNITED STATES IN 2009, BY STATE[1]

				Processing plants				
State	Active operations	Active quarries	Dredging operations	Stationary	Portable	Stationary and portable	None or unspecified	Sales yards
New Hampshire	28	26	--	17	8	1	--	2
New Jersey	25	20	--	12	1	6	1	5
New Mexico	49	48	--	12	31	2	3	1
New York	134	152	1	87	27	14	2	3
North Carolina	128	113	--	100	10	2	--	16
North Dakota	10	8	--	--	7	--	1	2
Ohio	112	101	--	69	21	8	3	11
Oklahoma	77	77	--	56	12	4	3	2
Oregon	171	185	--	49	112	3	3	4
Pennsylvania	262	260	--	195	28	11	20	8
Rhode Island	8	6	--	6	--	--	--	2
South Carolina	44	32	--	28	1	3	--	12
South Dakota	10	8	--	8	--	--	--	2
Tennessee	134	130	--	116	10	1	3	4
Texas	268	252	--	141	74	12	6	35
Utah	31	35	--	12	15	--	2	2
Vermont	45	44	--	21	16	3	4	1
Virginia	126	105	--	86	7	6	1	26
Washington	131	143	--	45	59	6	15	6
West Virginia	44	40	--	33	2	3	1	5
Wisconsin	152	210	--	49	87	4	6	6
Wyoming	28	26	--	8	15	3	--	2
Total	4,004	3,968	8	2,099	1,213	186	121	377

-- Zero.

[1] Includes recycling plants.

TABLE 17

U.S. EXPORTS OF CRUSHED STONE IN 2009, BY DESTINATION[1]

Destination		Limestone	Limestone for cement manufacturing	Chalk, crude	Granules, chippings	Other	Total
North America	metric tons	24,700	662,000	1,610	112,000	423,000	1,220,000
South America	do.	820	1,980	--	270	1,470	4,550
Europe	do.	181	4,070	49	421	3,580	8,310
Asia	do.	79	13,200	55	2,380	2,740	18,500
Oceania	do.	--	34	39	--	51	124
Middle East	do.	--	--	--	9	2,780	2,790
Africa	do.	--	--	--	4,570	86	4,660
Total:							
Quantity	do.	25,800	681,000	1,750	120,000	433,000	1,260,000
Value	thousands	$2,430	$17,000	$2	$21,800	$17,000	$58,300

do. Ditto. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 18
U.S. IMPORTS OF CRUSHED STONE AND CALCIUM CARBONATE FINES, BY TYPE[1]

	2008			2009		
Type	Quantity (thousand) metric tons)	Value, c.i.f.[2] (thousands)	Unit value	Quantity (thousand) metric tons)	Value, c.i.f.[2] (thousands)	Unit value
Crushed stone and chips:						
Limestone	11,700	$96,100	$8.24	3,900	$36,900	$9.45
Limestone for flux or cement manufacturing	1,880	20,300	10.77	1,040	9,490	9.15
Other	7,260	112,000	15.39	7,260	125,000	17.21
Total or average	20,800	228,000	XX	12,200	171,000	XX
Calcium carbonate fines:[3]						
Natural chalk	90	2,540	28.07	25	1,300	53.05
Calcium carbonates, other chalk	1	1,430	1,149.68	2	1,600	930.30
Total or average	91	3,960	XX	27	2,900	XX
Grand total or average	20,900	232,000	XX	12,200	174,000	XX

XX Not applicable.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Cost, insurance, and freight value.

[3] Excludes precipitated calcium carbonate.

Source: U.S. Census Bureau.

TABLE 19

THE TOP 100 PRODUCERS OF CRUSHED STONE IN THE UNITED STATES IN 2009[1]

Rank		Company
2009	2008	
1	1	Vulcan Materials Co.
2	2	Martin Marietta Aggregates
3	3	Lehigh Hanson, Inc.
4	4	Oldcastle Materials, Inc.
5	5	CEMEX S.A.B. de C.V.
6	6	Lafarge North America Inc.
7	7	Rogers Group, Inc.
8	8	Holcim Group/Aggregate Industries Management, Inc.
9	9	Carmeuse Lime & Stone
10	10	New Enterprise Stone & Lime Co., Inc.
11	11	Chemical Lime Co.
12	12	Luck Stone Corp.
13	13	Dolese Bros. Co.
14	52	U.S. Forest Service
15	15	Ash Grove Cement Co.
16	16	Ready Mix USA Holding Co.
17	22	Mulzer Crushed Stone, Inc.
18	18	Buzzi Unicem USA Inc.
19	20	Fred Weber, Inc.
20	14	Texas Industries, Inc.
21	24	Eucon Corp.
22	25	National Lime & Stone Co.
23	17	MDU Resources Group, Inc.
24	23	The H&K Group
25	19	Graymont Ltd.
26	21	Vecellio & Grogan, Inc.
27	27	Mississippi Lime Co.
28	33	Titan America LLC
29	29	Tower Rock Stone Co.
30	38	Bureau of Land Management
31	28	Eagle Materials Inc.
32	26	Texas Crushed Stone Co., Inc.
33	30	Boxley Materials Co.
34	44	Colas Inc.
35	36	Franklin Industries, Inc.
36	59	Capitol Aggregates, Ltd.
37	35	3M Co.
38	82	Mitsubishi Cement Corp.
39	39	Omya Inc.
40	37	ESSROC Cement Corp.
41	40	Wake Stone Corp.
42	50	Glenn O. Hawbaker, Inc.
43	31	Hunter Industries, Inc.
44	32	CalPortland Co.
45	42	Schildberg Construction Co., Inc.
46	46	Hoover, Inc.
47	41	American Infrastructure
48	45	Great Lakes Aggregates, Inc.
49	57	Hinkle Contracting Corp.
50	43	Irving Materials, Inc.
51	51	McGeorge Contracting Co.
52	69	Mining International LLC
53	47	Anchor Stone Co.
54	54	The Kraemer Co.
55	64	Laurel Sand & Gravel, Inc.
56	63	The Heritage Group
57	49	Norris Aggregate Products Co.
58	55	Trap Rock Industries, Inc.
59	46	Mathy Construction Co.
60	73	Columbia Quarry Co.
61	74	Pete Lien & Sons, Inc.
62	65	ISP Minerals, Inc.
63	58	Maryland Materials, Inc.
64	62	Alamo Cement Co.
65	48	Stavola Construction Materials, Inc.
66	94	RiverStone Group, Inc.
67	70	Imerys
68	91	Wendling Quarries Inc.
69	67	The Melvin Stone Co.
70	56	Greer Industries, Inc.
71	53	Granite Construction, Inc.
72	60	MGQ Aggregates, Inc.
73	79	Pine Bluff Sand & Gravel Co.
74	—	The DePaul Group
75	68	United States Lime and Minerals, Inc.
76	78	Unimin Corp.
77	—	Jobe Materials, L.P.
78	87	Basic Energy Services, Inc.
79	83	Midwest Minerals, Inc.
80	66	Bruening Rock Products, Inc.
81	80	Graniterock Co.
82	—	Pounding Mill Quarry Corp.
83	86	N.R. Hamm Quarry, Inc.
84	88	Laurel Aggregates, Inc.
85	—	Votorantim Cement North America
86	95	Snyder Associated Cos., Inc.
87	61	Palm Beach Aggregates, Inc.
88	98	Syar Industries Inc.
89	85	Kerford Limestone Co.
90	100	B.V. Hedrick Gravel & Sand Co., Inc.
91	92	River Products Co., Inc.
92	75	Chantilly Crushed Stone, Inc.
93	71	Leo Journagan Construction Co.
94	72	BMC Aggregates, L.C.
95	96	Weldon Materials, Inc.
96	—	Paul Niemann Construction Co.
97	—	Ronnie Duffield Gravel Co.
98	—	Frontera Materials, Inc.
99	—	Mertens Construction Co., Inc.
100	93	Glasgow, Inc.

— Not in the top 100 producers of crushed stone in the United States in 2008.

[1] In descending order of tonnage produced.

STONE, DIMENSION

By Thomas P. Dolley

Domestic survey data and tables were prepared by Samir Hakim, statistical assistant.

U.S. production of dimension stone in 2009 was estimated to be 1.62 million metric tons (Mt) valued at $328 million, which was a 10% decrease in tonnage and a slight increase in value compared with those of 2008 (table 1). Exports decreased in value by 27% to $48.3 million, and imports for consumption decreased in value by 37% to $1.35 billion. The value of apparent consumption was estimated to be $1.6 billion in 2009, which was a 32% decrease compared with that of 2008. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using unrounded data.

In recent years, most dimension stone has been used in construction applications, with the largest portions being sold or used as ashlars and partially squared pieces, curbing, flagstone, and rough block for building and construction. Monumental stone, another major type, includes memorials of various kinds.

Dimension stone is a natural rock material quarried for the purpose of obtaining blocks or slabs that meet specifications as to size (width, length, and thickness) and shape. Color, grain texture and pattern, and surface finish of the stone also are normal requirements by both customers and the stone industry. Durability (a time measure of the ability of dimension stone to endure and maintain its essential and distinctive characteristics), strength, and the ability of the stone to take a polish are other important selection criteria.

Although various igneous, metamorphic, and sedimentary rocks are used as dimension stone, the principal rock types are granite, limestone, marble, sandstone, and slate. Other varieties of dimension stone that are normally considered to be special minor types include alabaster (massive gypsum) and soapstone (massive talc). A more detailed discussion describing specific types of dimension stone can be found in the 2007 dimension stone Minerals Yearbook chapter.

Production

Dimension stone production data for the United States are derived by the U.S. Geological Survey (USGS) from a voluntary canvass of U.S. quarry producers of rough and dressed dimension stone. Of the 239 dimension stone-producing operations included in the survey for 2009, 132 (55%) responded, which represented 52% of the tonnage; the remaining tonnage was estimated based partly on prior years' reporting and partly on employment data provided by the Mine Safety and Health Administration (MSHA).

Data in this report cover rough crude quarried stone, irregular-shaped and rectangular blocks, and more highly processed stone. A number of other terms also are used to describe further processing, such as "worked," "dressed," "finished," and "manufactured." These and other terms used by the dimension stone industry describe such features as the mineral composition of the rock, the shape of the product, the method of finishing a stone, and the type of finish applied. No adjustments are made in the data to account for the sometimes substantial losses in processing rough stone into dressed stone. Sold or used data are considered to be equivalent to production because changes in stocks are not surveyed.

In 2009, limestone accounted for 548,000 metric tons (t) (34%) of the total domestic dimension stone production of 1.62 Mt, followed by granite (29%), miscellaneous stone (19%), sandstone (15%), marble (2%), and slate (1%). Granite accounted for about $111 million (34%) of the $328 million total domestic production value, followed by limestone (32%), miscellaneous (15%), sandstone (11%), marble (4%), and slate (4%).

Production of dimension stone was reported in 37 States. Leading producer States were, in descending order by tonnage, Texas, Wisconsin, Indiana, Georgia, and Vermont. These States accounted for about 56% of domestic production. Leading producer States were, in descending order by value, Texas, Indiana, Vermont, Wisconsin, and New York. These States contributed about 52% of the value of domestic production (table 3).

The top five producing companies were Buechel Stone Corp. in Wisconsin, Champlain Stone, Ltd. in New York, Eden Stone Co. Inc. in Wisconsin, Mezger Enterprises Inc. in Texas, and Swenson Granite Co. LLC in New Hampshire and Vermont. These companies produced about 27% of domestic production in tonnage and about 23% of production value. The leading 14 companies accounted for 50% of total domestically produced tonnage and 50% of the value.

Rough stone blocks split or cut from a quarry face are transported to processing plants that typically are located at the quarry site, at least for preliminary sizing. Further dressing, which includes final sizing and finishing operations, such as decorating, edging, and polishing, also may be done at the quarry site.

Granite.—Dimension granite was produced by 45 companies operating 74 quarries in 18 States. Production was 469,000 t valued at $111 million. Granite production tonnage increased by 1% and the value increased by about 4% compared with those of 2008. The top five producing States were, in descending order by tonnage, Georgia, Vermont, North Carolina, Massachusetts, and New Hampshire. Georgia accounted for 30% of the tonnage and 10% of the value of U.S. granite production (table 4).

Champlain Stone Ltd., Cold Spring Granite Co., Fletcher Granite Co., North Carolina Granite Corp., and Swenson Granite Co. LLC, which were the leading producers, accounted for 60% of U.S. granite production by tonnage and 73% of U.S. granite production by value.

Limestone.—Dimension limestone was produced by 37 companies from 50 quarries in 12 States. Production decreased in 2009 by about 9% to 548,000 t from 603,000 t in 2008.

The value increased by 21% to $106 million in 2009 from $87.9 million in 2008. The top four producing States were, in descending order by tonnage, Texas, Indiana, Wisconsin, and Arkansas. Indiana, Texas, and Wisconsin combined produced 87% of the U.S. tonnage and 81% of the value (table 5). Buechel Stone, Elliott Stone Co. Inc., Indiana Limestone Co., Mezger Enterprises, and Victor Oolitic Stone Co., which were the leading producers, accounted for 51% of all U.S. limestone tonnage and about 42% of the value.

Sandstone.—Dimension sandstone was produced by 57 companies that operated 70 quarries in 16 States. Production decreased by 28% to 248,000 t in 2009 from 346,000 t in 2008. The value decreased by 27% to $36.7 million in 2009 from $50.2 million in 2008. The top five producing States were, in descending order by tonnage, Arizona, Oklahoma, Ohio, Pennsylvania, and Arkansas (table 6).

Cornerstone Materials LLC, Drake Stone Products Inc., Flagstone Heights Inc., Harley Gray Stone Co., and Jude Stone Quarry Inc., which were the leading producers, accounted for about 45% of the tonnage and 41% of the value of domestic production.

Marble.—Marble was mined by five companies that operated six quarries in five States. Production tonnage decreased by 17% in 2009 to 35,300 t valued at $12.8 million from 42,600 t valued at $15.1 million in 2008 (table 10). Georgia was the leading producing State, followed by Vermont, Tennessee, Colorado, and Wisconsin. The leading producers were Georgia Marble Co. (a subsidiary of Polycor Inc.) and Vermont Quarries Corp.

Slate.—Slate was produced by 16 companies that operated 21 quarries in 6 States. Production decreased by 19% to 21,600 t in 2009 from 26,900 t in 2008. The value decreased by about 20% to $14 million in 2009 from $17.5 million in 2008 (table 12). The top producing States were Vermont, New York, and Pennsylvania. The leading producers were Newmont Slate Co., Inc., Ritchie Bros. Slate Co. Inc., and Western Slate Inc.

Consumption

For the purposes of this report, apparent consumption is calculated to be production plus imports for consumption minus exports; changes in industry stocks are not considered because such data are not available. Value data are used in the apparent consumption calculation because tonnage data are not available for imports and exports. Overall, the value of apparent consumption of dimension stone in the United States was estimated to be $1.6 billion in 2009; this was a 32% decrease compared with that of 2008.

Rough stone represented about 53% of the tonnage and 40% of the value of all dimension stone sold or used by domestic producers, which included exports. The leading uses of rough stone, by tonnage, were in building and construction (47%), and in irregular-shaped stone (30%). Dressed stone represented 47% by tonnage and 60% by value of the total stone sold or used. The leading uses within dressed stone, by tonnage, were in other uses (including panels and veneer, tile, blackboards, exports, unspecified uses, structural and sanitary, and unlisted uses) (27%); ashlars and partially squared pieces (24%); and curbing (19%) (table 7).

Uses for the different varieties of dimension stone varied considerably. The major uses of granite sold or used in 2009, by tonnage, were in curbing (29%), monumental rough stone (28%), rough blocks for building and construction (18%), and in other rough stone, including exports and unlisted uses (7%) (table 8). Primary uses of limestone, by tonnage, were in rough blocks for building and construction (37%), and in dressed stone for ashlars and partially squared pieces (24%) (table 9). Primary uses of marble, by tonnage, were in rough stone, other uses (including monumental stone, and unlisted and unspecified uses) (41%), and dressed stone (32%) (table 10). Primary uses of sandstone, by tonnage, were in dressed stone for flagging (32%) and in rough blocks for building and construction (27%) (table 11). Dimension slate sold or used by producers in the United States in 2009, by tonnage, was principally for roofing (73%), flagging (17%), and other uses (7%) (table 12).

Prices

The average 2009 value for dimension stone was $202 per metric ton, a 13% increase from 2008 based on the USGS canvass. The average unit values for different types of dimension stone were granite, $237 per ton; limestone, $193 per ton; marble, $363 per ton; sandstone, $147 per ton; and slate, $646 per ton. Available price data show considerable variation. Prices are substantially different not only for the kind of stone, but also for the appearance of the same kind of stone. Color, grain structure, and finish contribute significantly to price and marketability.

Foreign Trade

Exports.—In 2009, the value of total exports of dimension stone decreased by 27% in value to $48 million compared with those of 2008; granite accounted for 50% of the export value. The largest share of granite was exported to China (table 13). Although unreported, a significant amount of granite was probably exported back to the U.S. market.

Imports.—The value of imports for consumption of dimension stone types decreased by 37% in 2009 to $1.35 billion (table 1). Brazil was the leading source of imported granite in 2009, accounting for 37% by value. China, which continued to be a major source of granite, accounted for 28% of granite imports by value. Other important granite import sources included Italy (14%) and India (13%) (table 14). In 2009, China superseded Italy as a major source of rough and dressed marble import tonnage, but not value (tables 15, 16). Duties on imported dimension stone are listed in table 2.

World Review

World dimension stone production, including the United States, was estimated to be approximately 107 Mt in 2009. Although there was probably some small-scale production in the majority of the world's nations, dimension stone was produced and officially reported in about 29 countries. The top five producing countries in 2009 were, in descending order by tonnage, China, India, Turkey, Iran, and Italy, and these countries accounted for about 71% of the world's production.

Global production of dimension stone was unchanged in 2009 compared with that of 2008. The United States ranked 10th in world production of dimension stone in 2009 (Napoli, 2010, p. 63).

Outlook

The global economic downturn that commenced in late 2008 and continued through 2009 had a negative effect on both domestic and international sectors of the dimension stone industry. U.S. apparent consumption, production, exports, and imports of dimension stone all declined. The economic downturn resulted in decreased demand for the use of stone in both commercial and residential applications in 2009. Increased activity was observed in the U.S. dimension stone industry by yearend 2009 and continuing into 2010. Industry observers did not anticipate a recovery of the global dimension stone industry until 2010 (Napoli, 2010).

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TABLE 1

SALIENT U.S. DIMENSION STONE STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2005	2006	2007	2008	2009
Sold or used by producers:					
Quantity	2,000	1,850	1,920	1,800	1,620
Value	329,000	334,000	346,000	326,000 r	328,000
Exports, value	66,100	76,000	74,300	65,700	48,300
Imports for consumption, value	2,180,000	2,500,000	2,540,000	2,150,000	1,350,000

r Revised.

[1] Data are rounded to no more than three significant digits.

TABLE 2

U.S. IMPORT DUTIES ON DIMENSION STONE

Tariff item	HTS[1] code	NTR,[2] January 1, 2009	Non-NTR,[2] January 1, 2009
Slate, rough blocks or slabs	2514.00.0000	Free	25% ad valorem.
Rough blocks or slabs of marble, travertine, other calcareous monumental or building stone:	2515.00.0000		
Marble and travertine:			
Crude or roughly trimmed	2515.11.0000	Free	$22.95 per cubic meter.
Marble, merely cut	2515.12.1000	do.	13% ad valorem.
Travertine, merely cut	2515.12.2000	3.0% ad valorem	50% ad valorem.
Other calcareous stone alabaster	2515.20.0000	do.	Do.
Rough blocks or slabs of granite, porphyry, basalt, sandstone, other monumental or building stone:	2516.00.0000		
Granite:			
Crude or roughly trimmed	2516.11.0000	Free	$8.83 per cubic meter.
Merely cut	2516.12.0000	2.8% ad valorem	60% ad valorem.
Sandstone:			
Crude or roughly trimmed	2516.21.0000	Free	$5.30 per cubic meter.
Merely cut	2516.22.0000	3.0% ad valorem	50% ad valorem.
Other monumental or building stone	2516.90.0000	do.	Do.
Setts, curbstones, flagstones	6801.00.0000	2.8% ad valorem	60% ad valorem.
Worked monumental or building stone:	6802.00.0000		
Tiles and cubes under 7 centimeters square, granules	6802.10.0000	4.8% ad valorem	40% ad valorem.
Other stone and articles with a flat or even surface:			
Marble, travertine, and alabaster:	6802.21.0000		
Travertine	6802.21.1000	4.2% ad valorem	50% ad valorem.
Other	6802.21.5000	1.9% ad valorem	13% ad valorem.
Other calcareous stone	6802.22.0000	4.9% ad valorem	50% ad valorem.
Granite	6802.23.0000	3.7% ad valorem	60% ad valorem.
Other stone	6802.29.0000	6.0% ad valorem	30% ad valorem.
Other:			
Marble, travertine, and alabaster:	6802.91.0000		
Marble:			
Slabs	6802.91.0500	2.5% ad valorem	15% ad valorem.
Other	6802.91.1500	4.9% ad valorem	50% ad valorem.
Travertine:			
Travertine articles of subheading 6802.21.1000 that have been dressed or polished, but not further worked	6802.91.2000	4.2% ad valorem	50% ad valorem.
Other	6802.91.2500	3.7% ad valorem	40% ad valorem.
Alabaster	6802.91.3000	4.7% ad valorem	50% ad valorem.
Other calcareous stone	6802.92.0000	4.9% ad valorem	Do.
Granite	6802.93.0000	3.7% ad valorem	60% ad valorem.
Other stone	6802.99.0000	6.5% ad valorem	40% ad valorem.
Worked slate and articles:	6803.00.0000		
Roofing slate	6803.00.1000	3.3% ad valorem	25% ad valorem.
Other	6803.00.5000	Free	Do.

Do., do. Ditto.

[1] Harmonized Tariff Schedule of the United States.

[2] Normal trade relations.

TABLE 3

DIMENSION STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

State	2008		2009	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Alabama	6,720	$3,720	4,020	$1,460
Arizona	123,000	16,400	94,500	13,800
Arkansas	21,400	2,740	18,300	2,360
California	26,200	7,320	24,500	6,100
Colorado	27,500	4,510	10,600	3,110
Georgia	169,000	18,200	153,000	16,900
Idaho	33,600	4,130	25,200	3,370
Indiana	203,000	35,600	206,000	41,500
Kansas	19,900	2,560	29,200	4,650
Maine	7,120	1,720	5,800	1,300
Massachusetts	53,000	7,140	43,800	6,130
Minnesota	31,100	17,200	25,100	16,700
New Hampshire	33,800	4,900	34,800	4,880
New Mexico	26,600	939	32,300	986
New York	57,000	16,000	96,900	28,200
North Carolina	58,400	25,200	61,500	22,300
Ohio	28,700 [r]	3,660 [r]	25,800	4,790
Oklahoma	53,000	8,750	34,700	4,330
Pennsylvania	41,700	11,100	38,500	9,670
South Carolina	3,800	472	3,390	401
Texas	269,000	27,700	236,000	42,000
Utah	9,130	707	8,700	844
Vermont	112,000	35,900	108,000	30,000
Wisconsin	250,000	33,300	207,000	29,800
Other[2]	145,000 [r]	40,100 [r]	94,600	33,400
Total	1,800,000	326,000 [r]	1,620,000	328,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes Connecticut, Illinois, Maryland, Michigan, Missouri, Montana, Nevada, South Dakota, Tennessee, Virginia, Washington, West Virginia, and Wyoming.

TABLE 4
DIMENSION GRANITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

	2008		2009	
State	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
California	13,500	$4,600	13,300	$3,330
Georgia	153,000 r	11,600	140,000	11,300
Maine	7,120	1,720	5,800	1,300
Massachusetts	41,200	5,540	34,900	4,760
New Hampshire	33,800	4,900	34,800	4,880
North Carolina	50,300	23,900	49,300	21,000
South Carolina	3,800	472	3,390	401
Vermont	76,300	21,200	82,000	19,100
Other[2]	85,900	33,100	105,000	45,300
Total	465,000 r	107,000	469,000	111,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes Maryland, Minnesota, Missouri, New York, Oklahoma, Pennsylvania, South Dakota, Texas, Virginia, and Wisconsin.

TABLE 5
DIMENSION LIMESTONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

	2008		2009	
State	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Arkansas	1,080	$115	885	$98
Indiana	203,000	35,600	206,000	41,500
Texas	253,000	24,800	223,000	39,500
Wisconsin	81,100	8,800	49,100	4,730
Other[2]	65,100	18,600	69,200	20,400
Total	603,000	87,900	548,000	106,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes California, Illinois, Kansas, Maryland, Minnesota, Ohio, Oklahoma, and Pennsylvania.

TABLE 6
DIMENSION SANDSTONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

State	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)
Arizona	123,000	$16,400	94,500	$13,800
Arkansas	20,300	2,630	17,400	2,260
New York	53,300	13,700	15,900	3,350
Ohio	21,700 r	3,260 r	20,900	4,540
Oklahoma	39,600	7,190	22,600	3,000
Pennsylvania	14,100	2,290	19,300	2,370
Other[2]	78,000	7,430	57,800	7,320
Total	350,000 r	52,900 r	248,000	36,700

r Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes California, Colorado, Idaho, Kansas, Michigan, North Carolina, Texas, Utah, West Virginia, and Wisconsin.

TABLE 7
DIMENSION STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1, 2]

Use	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)
Rough stone:				
Rough blocks for building and construction	437,000 r	$55,700 r	402,000	$64,900
Irregular-shaped stone	273,000	30,800	259,000	27,800
Monumental	176,000 r	29,900 r	164,000	30,600
Other[3]	41,200	9,510	26,900	7,310
Dressed stone:				
Ashlars and partially squared pieces	246,000 r	46,700 r	185,000	42,200
Slabs and blocks for building and construction	67,000	13,200	66,500	22,000
Monumental	47,400 r	23,000 r	26,900	12,800
Curbing	98,900 r	11,400 r	145,000	19,300
Flagging	135,000	21,600	115,000	14,900
Flagging (slate)	4,860	2,730	3,640	2,270
Roofing slate	19,400	11,800	15,800	9,160
Flooring slate	789	905	640	933
Other[4]	258,000	69,100	206,000	73,700
Total	1,800,000	326,000 r	1,620,000	328,000

r Revised.

[1] Includes Puerto Rico.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Includes flagging stone, exports, uses not specified, and uses not listed.

[4] Includes panels and veneer, tile, blackboards, exports, uses not specified, structural and sanitary, and uses not listed.

TABLE 8

DIMENSION GRANITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

Use	2008		2009	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Rough stone:				
Rough blocks for building and construction	75,700 ^{r}	$13,900 ^{r}	84,000	$16,600
Irregular-shaped stone	4,630	653	13,800	1,060
Monumental	141,000 ^{r}	23,500	133,000	24,100
Other[2]	57,400	10,000	33,600	6,310
Dressed stone:				
Ashlars and partially squared pieces	6,610	3,570	12,100	3,910
Slabs and blocks for building and construction	3,670	975	920	1,090
Monumental	47,300 ^{r}	23,000 ^{r}	26,900	12,700
Curbing	92,100 ^{r}	9,930 ^{r}	138,000	18,500
Other[3]	36,200	21,500	27,100	27,000
Total	465,000 ^{r}	107,000	469,000	111,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes exports and uses not listed.

[3] Includes panels and veneer, tile, uses not specified, and uses not listed.

TABLE 9

DIMENSION LIMESTONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

Use	2008		2009	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Rough stone:				
Rough blocks for building and construction	232,000	$27,400	200,000	$33,500
Irregular-shaped stone	131,000	11,100	115,000	10,100
Other[2]	6,520	2,190	4,790	1,820
Dressed stone:				
Ashlars and partially squared pieces	136,000	23,600	133,000	28,200
Slabs and blocks for building and construction	22,500	3,100	28,600	10,100
Flagging	8,890	1,850	11,100	2,170
Other[3]	66,900	18,700	55,300	20,500
Total	603,000	87,900	548,000	106,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes exports, monumental, and uses not listed.

[3] Includes curbing limestone, panels and veneer, tile, uses not specified, and uses not listed.

TABLE 10

DIMENSION MARBLE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1, 2]

Use	2008		2009	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Rough stone:				
Rough blocks for building and construction	16,000	$3,350	9,610	$1,640
Other[3]	13,900	5,670	14,500	5,910
Dressed stone[4]	12,700	6,100	11,200	5,260
Total	42,600	15,100	35,300	12,800

[1] Includes Puerto Rico.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Includes monumental stone, uses not specified, and uses not listed.

[4] Includes slabs and blocks, flagging, monumental, panels and veneer, ashlars and partially squared pieces, tile, and uses not listed.

TABLE 11

DIMENSION SANDSTONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

Use	2008		2009	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Rough stone:				
Rough blocks for building and construction	94,200	$7,760 r	67,100	$6,890
Irregular-shaped stone	8,580	1,490	37,800	5,590
Other[2]	36,800	6,330	17,000	3,270
Dressed stone:				
Ashlars and partially squared pieces	68,000 r	12,900 r	21,400	4,080
Slabs and blocks for building and construction	26,500	5,860	3,880	871
Flagging	83,100	10,000	79,200	9,360
Panels and veneer	10,300	1,960	6,280	1,370
Other[3]	22,200	6,640	15,700	5,220
Total	350,000 r	52,900 r	248,000	36,700

r Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes flagging stone and uses not listed.

[3] Includes tile, curbing, exports, uses not specified, and uses not listed.

TABLE 12

DIMENSION SLATE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

Use	2008		2009	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Flagging	4,860	$2,730	3,640	$2,270
Roofing	19,400	11,800	15,800	9,160
Flooring	789	905	640	933
Other[2]	1,810	2,060	1,600	1,620
Total	26,900	17,500	21,600	14,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes structural and sanitary purposes, uses not specified, and uses not listed.

TABLE 13

U.S. EXPORTS OF DIMENSION STONE, BY TYPE[1]

(Thousand metric tons and thousand dollars)

Type	2008		2009		Major destination in 2009[2]
	Quantity	Value	Quantity	Value	
Marble, travertine, alabaster worked[3]	49	7,740	43	5,580	Canada, 45%.
Marble, travertine, crude or roughly trimmed	4	1,530	2	1,250	Canada, 39%.
Marble, travertine, merely cut, by sawing or otherwise[4]	14	3,120	4	2,010	United Arab Emirates, 27%.
Granite, crude or roughly trimmed	95	32,600	67	20,800	China, 54%.
Granite, merely cut by sawing or otherwise[4]	8	4,120	8	3,310	China, 24%.
Sandstone, crude or roughly trimmed	NA	NA	NA	NA	NA.
Sandstone, merely cut, by sawing or otherwise[4]	NA	NA	NA	NA	NA.
Slate, worked and articles of slate	NA	3,810	NA	4,340	Singapore, 47%.
Slate, whether or not roughly trimmed or merely cut[4]	NA	633	NA	789	Latvia, 25%.
Other calcareous monumental or building stone; alabaster[5]	29	7,650	22	6,290	Canada, 93%.
Other monumental or building stone[6]	10	4,460 r	15	3,870	Canada, 67%.
Total	XX	65,700	XX	48,300	

r Revised. NA Not available. XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] By value.

[3] Further worked than simply cut with a flat surface.

[4] Blocks or slabs.

[5] Crude, roughly trimmed, or merely cut into blocks or slabs. Other than marble and travertine (includes alabaster).

[6] Crude, roughly trimmed, or merely cut into blocks or slabs. Other than calcareous stone and alabaster, granite, sandstone, slate, dolomite, quartzite, and steatite.

Source: U.S. Census Bureau.

TABLE 14
U.S. IMPORTS FOR CONSUMPTION OF DIMENSION GRANITE, BY COUNTRY[1]

(Thousand dollars)

		Dressed								
			Worked granite							
				Cut to size[2]						
Country	Rough granite[3]	Simply cut[4]	Not cut to size[5]	Maximum 1.5 centimeters	1.5–7.5 centimeters	Monumental minimum 7.5 centimeters	Building minimum 7.5 centimeters	Other	Total worked	Total dressed
2008:										
Argentina	163	19	237	18	1,130	--	--	175	1,560	1,580
Brazil	1,850	16,100	95,400	4,490	266,000	78	4,050	38,600	409,000	425,000
Canada	3,720	722	1,310	2,940	9,350	9,850	4,850	3,780	32,100	32,800
China	4,950	29,200	15,000	19,500	139,000	14,900	19,900	59,900	268,000	297,000
Finland	2	--	--	--	67	--	5	21	93	93
India	12,300	14,400	24,600	4,440	88,500	8,760	3,370	25,700	155,000	170,000
Italy	938	8,440	33,600	3,330	124,000	139	5,310	32,400	199,000	208,000
Japan	6	19	--	--	292	19	248	8	567	586
Mexico	--	839	12	4	92	--	132	454	694	1,530
Norway	168	20	--	--	137	--	6	22	165	185
Portugal	23 r	104	35	335	291	--	--	142	803	907
Saudi Arabia	--	--	--	--	249	--	5	48	302	302
South Africa	1,900	125	190	--	215	--	34	114	553	678
Spain	71	1,790	1,610	249	8,910	--	217	1,010	12,000	13,800
Zimbabwe	118	--	--	--	41	--	--	--	41	41
Other	955 r	5,750	7,720	4,050	18,200 r	237	1,810	5,090	37,100	42,900
Total	27,200	77,500	180,000	39,300	657,000	34,000	39,900	167,000	1,120,000	1,190,000
2009:										
Argentina	192	3	83	--	486	--	--	21	590	593
Brazil	722	2,660	60,200	3,410	184,000	67	3,010	30,400	281,000	284,000
Canada	3,130	471	1,660	2,290	6,870	9,980	1,790	3,090	25,700	26,200
China	1,690	15,600	9,610	14,200	105,000	12,900	11,400	46,600	200,000	216,000
Finland	10	--	--	--	25	--	--	13	38	38
India	5,430	4,140	13,300	2,140	49,100	8,930	2,390	15,500	91,300	95,500
Italy	553	1,580	16,400	1,720	65,400	--	3,420	16,200	103,000	105,000
Japan	2	--	--	--	9	--	193	11	213	213
Mexico	5	181	--	--	83	--	10	207	300	481
Norway	230	6	--	12	35	--	--	16	63	69
Portugal	--	24	20	45	139	--	37	223	464	488
Saudi Arabia	--	--	--	--	166	--	3	29	198	198
South Africa	658	3	54	--	150	--	4	24	232	235
Spain	69	315	570	289	5,650	--	31	811	7,350	7,670
Zimbabwe	1,900	--	--	--	--	--	--	--	--	--
Other	744	2,020	6,110	756	14,300	122	772	3,210	25,300	27,300
Total	15,300	27,000	108,000	24,800	432,000	32,000	23,100	116,000	736,000	763,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] One or more faces worked more than simply cut.

[3] Normal quarry products. Includes crude or roughly trimmed and roughly cut by sawing or otherwise; Harmonized Tariff Schedule of the United States (HTS) codes 2516.11.0000, 2516.12.0030, and 2516.12.0060.

[4] Simply cut with a flat even surface; HTS code 6802.23.0000.

[5] Only one face worked more than simply cut; HTS code 6802.93.0010.

Source: U.S. Census Bureau.

TABLE 15

U.S. IMPORTS FOR CONSUMPTION OF MAJOR CATEGORIES OF DIMENSION MARBLE AND OTHER CALCAREOUS STONE, BY COUNTRY[1]

	Dressed							
	Marble, slabs[2]		Marble, other[3]		Other calcareous stone[4]		Rough marble[5]	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2008:								
Brazil	3,970	3,970	292	322	1,520	1,780	31	112
Canada	158	335	998	2,490	8,430	7,870	5	14
China	44,400	36,300	55,900	64,900	17,000	16,800	1,940	1,520
France	108	250	349	913	61,700	17,100	5	53
Greece	6,120	11,700	7,440	8,900	892	1,530	1	8
India	6,170	6,300	3,160	6,330	4,810	3,720	37	102
Israel	6,440	4,510	6,230	5,820	32,500	17,300	1,690	66
Italy	67,500	125,000	48,700	85,800	92,500	35,800	511	1,520
Lebanon	137	61	555	2,050	488,000	15,400	--	--
Mexico	1,160	1,120	5,900	8,160	30,900	10,500	69	73
Portugal	2,310	3,050	1,830	3,600	28,500	18,100	--	--
Spain	29,600	32,200	25,200	28,500	98,000	19,400	658	524
Taiwan	815	895	1,690	2,820	177	261	--	--
Turkey	22,600	20,400	71,500	60,800	192,000	12,000	145	189
Other	16,800 r	17,400 r	26,100 r	25,700 r	32,700 r	25,800 r	533	252
Total	208,000	263,000	256,000	307,000	1,090,000	203,000	5,630	4,430
2009:								
Brazil	1,680	1,680	170	193	715	955	22	36
Canada	151	438	455	1,900	9,230	5,420	1	3
China	47,500	33,700	43,900	49,000	36,200	13,400	1,970	865
France	37	185	185	609	5,710	10,500	3	7
Greece	3,600	8,110	2,530	4,850	479	785	--	--
India	3,830	3,700	2,120	3,580	3,850	2,700	6	19
Israel	2,720	3,500	3,700	3,710	5,180	6,180	--	--
Italy	41,600	80,100	25,800	43,500	14,600	18,500	376	481
Lebanon	4	3	524	991	469,000	5,650	22	12
Mexico	393	468	2,070	2,800	5,810	6,130	142	28
Portugal	1,220	1,530	908	1,740	14,200	13,800	4	16
Spain	18,000	17,100	14,900	17,200	12,000	11,800	448	227
Taiwan	437	506	1,120	2,120	80	88	5	30
Turkey	19,400	15,400	49,400	38,900	44,400	6,030	175	132
Other	10,900	9,910	14,100	13,400	41,300	12,700	299	157
Total	151,000	176,000	162,000	185,000	663,000	115,000	3,470	2,010

rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Worked more than simply cut with a flat surface; Harmonized Tariff Schedule of the United States (HTS) code 6802.91.0500.

[3] Merely cut by sawing or otherwise.

[4] Worked more than simply cut with a flat surface, other than marble and travertine; HTS code 6802.92.0000.

[5] Simply cut by sawing or otherwise into rectangular blocks or slabs; HTS code 2515.12.1000.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 16

U.S. IMPORTS FOR CONSUMPTION OF DIMENSION STONE, BY TYPE[1]

Type		2008 Quantity	2008 Value (thousands)	2009 Quantity	2009 Value (thousands)	Major source for 2009[2]
Calcareous stone, other[3]	metric tons	NA	NA	NA	NA	NA.
Marble and alabaster[4]	do.	18,600	$23,400	12,300	$16,000	Italy, 34%.
Sandstone, cut, by sawing or otherwise[5]	do.	NA	NA	NA	NA	Italy, NA.
Slate, roofing	million square feet	11	8,560	6	5,910	Canada, 35%.
Slate, roughly trimmed or simply cut[5]	do.	7,980	3,260	3,190	1,220	China, 45%.
Slate, worked and articles of slate, and other[6]	do.	NA	89,200	NA	56,000	China, 44%.
Travertine, monumental or building stone and articles thereof[7]	do.	45,400	23,100	14,600	13,000	Mexico, 27%.
Travertine, worked monumental or building stone[8]	do.	45,100	32,100	21,200	16,300	China, 31%.
Other stone, monumental or building stone[9]	do.	NA	NA	NA	NA	Turkey, NA.

do. Ditto. NA Not available.

[1] Data are rounded to no more than three significant digits. Table does not include totals shown on tables 14 and 15.

[2] By value.

[3] Simply cut with a flat surface, other than marble, travertine, and alabaster.

[4] Simply cut with a flat surface.

[5] Rectangular blocks or slabs.

[6] Other than roofing, including agglomerated slate.

[7] Simply cut with a flat surface, other than tiles and granules.

[8] Dressed or polished but not further worked.

[9] Simply cut with a flat surface, other than granite, calcareous stone, alabaster, slate, dolomite, quartzite, and steatite.

Source: U.S. Census Bureau.

STRONTIUM

By Marc A. Angulo

Domestic survey data and tables were prepared by Virginia C. Harper and Shonta E. Osborne, statistical assistants, and the world production table was prepared by Lisa D. Miller, international data coordinator.

Domestic apparent strontium consumption increased in 2009, attributed primarily to an increase in imported celestite. The 11,800 metric tons (t) of strontium content consumed in 2009 is dramatically lower than the nearly 38,000 t consumed at its peak in 1997. The decline in consumption during this period is a direct consequence of the decline in color television faceplate glass production, strontium's major end use since the early 1970s. Demand has increased for flat panel technology as an alternative to cathode-ray tubes (CRTs) for television displays, which requires little to no strontium carbonate. World production of celestite decreased by about 39% as a result of reduced production in Mexico, Spain, and Turkey, which also was attributed to the shift to flat panel technology.

Strontium composes about 0.04% of the Earth's crust, ranking 15th among elements in abundance (MacMillan and others, 2005). Only two minerals, however, celestite (strontium sulfate) and strontianite (strontium carbonate), contain strontium in sufficient quantities to make recovery practical. Of the two, celestite occurs much more frequently in sedimentary deposits of sufficient size to make development of mining facilities attractive. Neither mineral is mined in the United States, although deposits have been identified and were mined in the past.

Legislation and Government Programs

Strontium may be found in trace amounts in drywall, but he occurrence of foul odor, electrical corrosion, and illness associated with many Florida homes fitted with Chinese-manufactured drywall led State and Federal investigators o suspect the presence of elevated strontium sulfide levels. Strontium sulfide can react with moist air to produce hydrogen sulfide emitting a foul odor and causing corrosion. An initial study conducted by the Florida Department of Health found race amounts of strontium sulfide in Chinese drywall and none n domestic drywall. The Environmental Protection Agency EPA) found elevated strontium and sulfur levels in Chinese drywall. The U.S. Consumer Product Safety Commission CPSC) conducted an air quality study on 51 affected homes and found high levels of hydrogen sulfide. The EPA and CPSC were conducting expanded studies and results were expected n the summer of 2010 (Florida Department of Health, 2009a, b; U.S. Consumer Product Safety Commission, 2009; U.S. Environmental Protection Agency, 2009).

Production

Although strontium carbonate was not produced in the United States in 2009, strontium carbonate was the principal strontium compound produced globally in 2009, and most other strontium compounds were derived from strontium carbonate. Domestic production of strontium carbonate ceased in 2006 when Chemical Products Corp. (CPC) of Cartersville, GA, closed its strontium carbonate and strontium nitrate operations. A few companies produced small quantities of downstream strontium chemicals elsewhere in the United States.

Consumption

Celestite is typically used as the raw material in strontium carbonate production and is consumed directly in small quantities as an alternative to barium sulfate as white filler in industrial products. Strontium carbonate is used directly in some applications and is also converted into appropriate downstream chemicals such as strontium chloride, strontium hydroxide, or strontium nitrate.

With the closure of CPC's strontium operations, an accurate estimation of domestic end uses has become difficult to obtain. The entire strontium consumption scenario has been reconfigured because television faceplate glass is no longer produced in the United States; thus, what was once the dominant end use is no longer a factor. At its peak, as much as 75% of all strontium consumption in the United States was used in faceplate glass for CRTs.

Even without strontium carbonate consumption in CRT displays, ceramics and glass manufacturing remained one of its top end uses. Permanent ceramic ferrite magnets are used extensively in small direct current motors for automobile windshield wipers, loudspeakers, magnetically attached decorative items, toys, and other electronic equipment. Strontium ferrite magnets possess chemical and physical properties ideal for use in these applications. They retain their magnetism well, are not adversely affected by electrical currents or high temperatures, do not react with most chemical solvents, and have a low density (Haberberger, 1971). Strontium oxide and strontium carbonate are used as frits in ceramic glazes as a nontoxic alternative to barium and lead (Yunpeng, 2009). Strontium oxide is used as a glass modifier to increase hardness and strength, enhance optical glass properties, and increase light refraction. Strontium glass is colorless and absorbs ultraviolet and x-ray radiation, an ideal glass for CRT faceplates. The fiberglass, lab glass, and pharmaceutical glass industries consume strontium in smaller amounts (Solvay S.A., 2010b).

One of the most consistent and continuing applications for strontium is its use in pyrotechnics as a coloring agent. While undergoing combustion, strontium emits a brilliant red hue. Strontium nitrate is used most often as a coloring agent, but strontium carbonate, strontium chlorite, strontium oxalate, and strontium sulfate can also be used. Strontium pyrotechnic applications include civilian and military flares, fireworks, and tracer ammunition (Conkling, 1981).

Recent research suggested that using nitrogen-base instead of carbon-base oxidizers reduced the amount of smoke emitted when deploying pyrotechnic products. By minimizing smoke, lower quantities of coloring agents were required to produce the same color intensities. The new technology could reduce the amount of coloring agents from 30% to 5%, by weight. Although the cost associated with this technology was high, these products found niche markets in indoor or environmentally friendly fireworks displays. If the cost fell and new environmental regulation was enacted, the consumption of strontium in this market was likely to decrease (Halford, 2008).

Strontium is used in a few metallurgical applications. Small quantities of strontium metal can be added to molten aluminum to improve the machinability of castings used in automotive engine blocks and wheels (Lidman, 2002). Strontium can be used to remove lead impurities during the electrolytic production of zinc. The addition of strontium carbonate dissolved in sulfuric acid reduces the lead content of the electrolyte and of the zinc deposited on the cathode (Solvay S.A., 2010a).

Small quantities of strontium and strontium compounds were consumed by other industries. Strontium chromate was incorporated into paints as a corrosion inhibitor, effectively coating aluminum used in the construction of aircraft fuselages and ships (Roskill Information Services Ltd., 1992, p. 76). Strontium chromate, however, was classified as a carcinogen in humans, leading many in the paint industry to seek safer alternatives (Raurell and others, 2010). Other strontium compounds were used as catalysts to accelerate the drying of oils, paints, and printing inks (Springate and others, 2009).

The drug strontium ranelate, a strontium salt of ranelic acid, has been used to reduce the incidence of fractures in osteoporotic patients by promoting the uptake of calcium into bones (Nielsen, 2004). The isotope strontium-89 has been used successfully in medical trials for the treatment of pain associated with advanced metastatic cancer (Porter, 1994). Strontium chloride is used in toothpaste to treat tooth-sensitivity caused by temperature and pressure.

Strontium exhibits a high dielectric constant, making it an attractive material for use in wireless devices and memory chips. Strontium titanate is sometimes used as a substrate material for semiconductors and in some optical and piezoelectric applications. As the technology improves and costs decrease, high-tech industries are likely to consume more strontium (McCoy, 2009; McIntosh, 2009).

Strontium oxide aluminate is used as a phosphorescent (glow-in-the-dark) pigment in applications such as emergency exit signs that glow brighter and longer than those using more-common photoluminescent pigments (Merit Lighting, LLC, 2008). Strontium phosphate is used in the manufacture of fluorescent lights, and the entire range of strontium chemicals is used in analytical chemistry laboratories.

Prices

Based on data published by the U.S. Census Bureau, the average customs unit value for celestite imported from Mexico was $47.11 per metric ton, a decrease of 26% compared with that of 2008. The average unit customs value of imported strontium carbonate was $0.65 per kilogram, a decrease of 3% from $0.67 per kilogram in 2008. In 2009, the unit value of imported strontium metal increased to $8.05 per kilogram from $4.66 per kilogram. In 2009, the corresponding value for strontium nitrate was $1.00 per kilogram, which was 12% less than that of 2008.

Foreign Trade

With the modification of the domestic strontium market—strontium carbonate consumption for CRTs production shifting to Asia and the continued consumption of strontium compounds for ceramics, glass, and pyrotechnics—strontium exports from and imports into the United States became erratic from year to year. Adequate information to explain the variations is unavailable; however, trends have appeared during the past [illegible] years. Imports of celestite from Mexico were 14,600 t in 2009, more than 3 times the amount imported in 2008 and 11 times the amount imported in 2007 (table 1). Imports of strontium metal in 2009 were 70 t, exhibiting a steady decrease since reaching its peak of 770 t in 2005. Imports of strontium nitrate in 2009 decreased by 29% after 4 consecutive years of increase from 2005 to 2008, but were more than four times the imports of 2004, when CPC was still producing strontium nitrate at its Georgia plant. Imports of strontium carbonate have decreased steadily since 2005, and exports remained relatively low compared with their peak of 49,000 t in 2000.

Strontium exports from the United States have been decreasing every year since 2006. Total strontium exports in 2009 decreased to 773 t, an 11% decrease from the revised exports of 2008. Exports to Belgium, Germany, and the Republic of Korea represent 64% of total strontium exports by gross weight (table 2).

Strontium imports increased during the past 2 years, although total strontium imports decreased substantially from 2002 to 2007. Imports totaled 25,300 t (gross weight) in 2009 (table 3), an increase of 18% from that of 2008 and a 56% increase from that of 2007. Mexico continued to be a major source of imported strontium compounds, contributing more than 91% of total imports. Chinese strontium imports decreased from [illegible] in 2008 to 719 t in 2009, driven in large part by a 70% decrease in strontium carbonate imports. With uncertainty surrounding the Spanish strontium production owing to the closure of the Montevive celestite mine in Granada and the global economic recession affecting the Spanish industrial minerals market, Spanish strontium imports decreased by 17% in 2009 (O'Driscoll, 2009; Moores, 2010).

World Review

Large deposits of high-grade celestite have been discovered throughout the world, but active mines are primarily in China, Iran, Mexico, Spain, and Turkey. Smaller operations are in Argentina, Morocco, and Pakistan. Many large deposits are not economically feasible to mine owing to high levels of barium and calcium, impurities requiring energy-intensive and cost-prohibitive methods for separation. Most strontium producers require a minimum of 90% strontium sulfate content to achieve profitability. Hand sorting and some washing are all that are essary at many strontium mines; a few operations use froth ation, gravity separation, or other methods to beneficiate ore.

he leading celestite-producing countries were, in decreasing er of output, China, Spain, and Mexico comprising 96% of l celestite produced worldwide. Turkey had been another ding celestite producer but has experienced significant lines in production in recent years, and no celestite was duced in 2009. Celestite was produced in small quantities rgentina, Morocco, Iran, and Pakistan (table 4). Production ilities for strontium compounds and metal were located anada, China, Germany, Japan, the Republic of Korea, xico, and the United States, although the current status of ne of these operations is unknown.

wing to decreased demand for CRTs and increased npetition in the Chinese market, the Montevive celestite ie in Granada (operated by Bruno SA) closed in late 2009. Belgian chemical producer Solvay Minerales SA was only remaining Spanish producer of celestite. Spanish estite production decreased significantly in 2009 and further duction decreases were expected in coming years. The nian celestite industry was expected to expand during the t 3 years owing to strong Chinese demand, low cost of tainer freight, and government subsidies. Production was ected to reach between 2,000 and 20,000 tons per year 'Driscoll, 2009).

tlook

The production of CRT televisions and computer monitors xpected to cease as flat screen devices, requiring little or no ontium, become more accessible. Faceplate glass and smaller evisions with CRTs still are produced in Asia and Mexico, ere they now are being built for local consumption and port. Strontium demand for CRTs has begun to decline in Asia d Mexico, and newer display technology is likely to replace Ts in those markets as well.

Strontium use in pyrotechnics is expected to continue; wever, the strontium consumption in pyrotechnics is likely decline slowly as substitutes are developed that enable less ontium nitrate to be used to achieve the same color intensities. rrite magnet markets are expected to be strong, and demand r strontium is likely to continue for this use. As technologies prove, consumption of strontium in new applications may crease. Improved economic conditions worldwide could spur owth in demand for strontium carbonate in more traditional plications, but it is unlikely that television and monitor glass ll ever represent the dominant end use for strontium that it ce did.

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TABLE 1
SALIENT STRONTIUM STATISTICS[1]

(Metric tons of contained strontium and dollars per metric ton unless otherwise noted)[2]

	2005	2006	2007	2008	2009
United States:					
Production, strontium minerals	--	--	--	--	--
Imports for consumption:[3]					
Strontium compounds	11,700	8,860	8,550	9,420	5,860
Strontium minerals	799	671	541	2,030	6,420
Exports, compounds[3]	211 r	699 r	688 r	594 r	532
Shipments from Government stockpile excesses	--	--	--	--	--
Apparent consumption[4]	12,300	8,830	8,400 r	10,900 r	11,800
Price, average value of mineral imports at port of exportation	56	64	67	64	47
World, production of celestite, gross weight	509,000	524,000 r	518,000 r	656,000 r	402,000 e

eEstimated. rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits.

[2] The strontium content of celestite is 43.88%, which was used to convert units of celestite.

[3] Source: U.S. Census Bureau.

[4] Production plus imports minus exports.

TABLE 2

U.S. EXPORTS OF STRONTIUM COMPOUNDS, BY COUNTRY[1]

	2008		2009	
	Gross weight (kilograms)	Value[2]	Gross weight (kilograms)	Value[2]
Strontium carbonate, precipitated:				
Canada	37,400	$40,100	30,900	$32,200
Germany	--	--	3,840	3,650
Japan	--	--	13,100	21,800
Korea, Republic of	62,600	59,500	--	--
Mexico	18,100	14,100	102,000	41,100
Netherlands	--	--	6,320	6,000
United Kingdom	--	--	2,780	2,640
Total	118,000	114,000	159,000	107,000
Strontium oxide, hydroxide, peroxide:				
Argentina	117,000	64,400	--	--
Belgium	29,300	16,100	215,000	121,000
Brazil	7,570 [r]	11,900 [r]	--	--
Canada	161,000	76,300	--	--
China	1,000	5,260	--	--
Colombia	30,700	16,900	--	--
France	189,000	297,000	--	--
Germany	19,100 [r]	10,500 [r]	176,000	97,000
Israel	63,300	34,800	11,000	6,070
Italy	37,000	42,400	--	--
Japan	12,100 [r]	6,630 [r]	25,600	14,100
Korea, Republic of	28,400	15,600	102,000	56,100
Norway	4,550	2,500	--	--
Spain	-- [r]	-- [r]	--	--
Sweden	22,900	12,600	18,400	10,100
Switzerland	--	--	27,900	15,300
Taiwan	18,000 [r]	24,100 [r]	38,000	34,700
Trinidad	--	--	747	3,240
United Kingdom	7,640	4,200	--	--
Total	749,000 [r]	641,000 [r]	615,000	358,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship value.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 3

U.S. IMPORTS FOR CONSUMPTION OF STRONTIUM COMPOUNDS, BY COUNTRY[1]

	2008		2009	
	Gross weight (kilograms)	Value[2]	Gross weight (kilograms)	Value[2]
Celestite, Mexico	4,620,000	$295,000	14,600,000	$690,000
Strontium carbonate:				
China	2,000,000	2,890,000	600,000	693,000
Germany	1,490,000	877,000	1,240,000	703,000
Italy	7,000	34,900	20,400	124,000
Mexico	9,240,000	4,750,000	5,890,000	3,500,000
Spain	--	--	72,600	64,900
United Kingdom	25	13,400	25	9,720
Total	12,700,000	8,560,000	7,820,000	5,090,000
Strontium metal:				
Brazil	4,090	22,100	--	--
Canada	47	2,200	--	--
China	60,700	326,000	20,200	149,000
Japan	103,000	410,000	30,400	71,200
Korea, Republic of	2,340	22,500	--	--
Switzerland	16	8,660	19,500	344,000
Total	170,000	791,000	70,100	564,000
Strontium nitrate:				
Canada	--	--	1,700	5,700
China	312,000	310,000	93,600	115,000
Japan	256,000	726,000	58,000	178,000
Mexico	3,130,000	3,230,000	2,550,000	2,410,000
Spain	170,000	152,000	68,500	59,900
Taiwan	16,700	15,200	--	--
Total	3,890,000	4,430,000	2,770,000	2,770,000
Strontium oxide, hydroxide, peroxide:				
China	104,000	103,000	5,450	36,000
Germany	1,400	23,500	--	--
Japan	601	20,700	300	9,400
Korea, Republic of	200	5,150	974	5,370
Total	106,000	152,000	6,720	50,800

-- Zero.

[1] Data rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship value.

Source: U.S. Census Bureau.

TABLE 4
CELESTITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Argentina	7,233	19,822	4,904	14,910 [r]	10,000
China[e]	180,000	180,000	190,000	200,000	210,000
Iran[e, 4]	672 [5]	1,000 [r]	2,000 [r]	2,000 [r]	2,000
Mexico	110,833	125,000	125,000 [e]	96,902	37,601 [5]
Morocco[e]	2,700	2,700	2,700	2,700	2,600
Pakistan	1,855	1,466	1,600 [e]	1,700 [e]	1,800
Spain[e]	188,000	188,000	188,000	336,000 [r, 5]	138,000 [5]
Turkey[e]	18,000	6,300	4,200	1,600	--
Total	509,000	524,000 [r]	518,000 [r]	656,000 [r]	402,000

[e] Estimated. [r] Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 16, 2010.

[3] In addition to the countries listed, Tajikistan was thought to produce celestite, but information was not available to make reliable estimates.

[4] Data are for year beginning March 21 of that stated.

[5] Reported figure.

SULFUR

By Lori E. Apodaca

Domestic survey data and tables were prepared by Robin C. Kaiser, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2009, the sulfur price began the year at its lowest level in U.S. history. The U.S. market was suffering from a downturn in demand for goods in all sectors. In the fertilizer industry, the phosphate sector, which includes seven U.S. producers, was operating at levels of about 25% of capacity in an attempt to continue production with essentially no demand. In May, prices began to move upwards. In the last quarter of the year, market conditions improved slightly as production and consumption of phosphate rock and fertilizers increased.

The United States was second in world sulfur production, with China's sulfur production surpassing that of the United States for the first time. Elemental sulfur and byproduct sulfuric acid produced as a result of efforts to meet environmental requirements that limit atmospheric emissions of sulfur dioxide were the dominant sources of sulfur around the world.

Through its major derivative, sulfuric acid, sulfur ranks as one of the most important elements used as an industrial raw material and is of prime importance to every sector of the world's fertilizer and manufacturing industries. Sulfuric acid production is the major end use for sulfur, and consumption of sulfuric acid has been regarded as one of the best indexes of a nation's industrial development. More sulfuric acid is produced in the United States every year than any other inorganic chemical; 29.1 million metric tons (Mt), which is equivalent to about 9.5 Mt of elemental sulfur, was produced in 2009, 8% less than in 2008 (U.S. Census Bureau, 2010).

In 2009, domestic production of sulfur in all forms was 4% lower than 2008; shipments of sulfur in all forms decreased by about 5%. Elemental sulfur recovered at petroleum refineries was 4% lower than it was in 2008, and sulfur recovered from natural gas operations decreased by 7%. Producers' stocks increased by 10%, representing about 3% of shipments. Byproduct sulfuric acid production and shipments declined slightly. Apparent consumption of sulfur in all forms decreased by 27%. Imports of elemental sulfur and sulfuric acid combined decreased by 55%. Exports increased by 45%, primarily as a result of a large increase in elemental sulfur exports. The average unit value in 2009 was the lowest recorded value dating as far back as 1900 for the United States, resulting in the value of elemental sulfur shipments decreasing by almost 99% compared with the 2008 value of shipments. The total value of byproduct sulfuric acid shipments more than doubled, even though the quantity of shipments decreased by about 5% (table 1).

Worldwide, compliance with environmental regulations has contributed to sulfur recovery; however, in 2009 there was a slight decrease in sulfur production. Recovered elemental sulfur is produced primarily during the processing of natural gas and crude petroleum. Estimated worldwide production of native (naturally occurring elemental) sulfur decreased by 23%. In the few countries where pyrites remain an important raw material for sulfuric acid production, strong demand resulted in a slight increase in sulfur production from pyrites.

Since 2003, between 82% and 84% of the world's sulfur production as elemental sulfur and byproduct sulfuric acid came from recovered sources. Some sources of sulfur were unspecified, which means that the material could have been, and likely was, elemental sulfur or byproduct sulfuric acid, raising the percentage of byproduct sulfur production to about 90% annually. The quantity of sulfur produced from recovered sources was dependent on the world demand for fuels, nonferrous metals, and petroleum products rather than for sulfur.

World sulfur consumption was thought to be slightly lower than it was in 2008; typically, about 50% was used in fertilizer production, and the remainder, in myriad other industrial uses. World trade of elemental sulfur decreased slightly from the levels reported in 2008. Worldwide inventories of elemental sulfur were higher.

Legislation and Government Programs

In December, the U.S. Environmental Protection Agency (EPA) finalized more stringent standards for control of emissions from new marine compression-ignition engines at or above 30 liters per cylinder. EPA's strategy included Clean Air Act standards, as well as implementation of the international standards for marine engines and their fuels contained in Annex VI to the International Convention on the Prevention of Pollution from Ships (MARPOL). Also included in these standards was the designation of U.S. coasts as an Emission Control Area (ECA) through an amendment to MARPOL Annex VI.

The final rule provided flexibility on complying with fuel sulfur requirements. Vessels could use other methods to achieve sulfur dioxide emission reductions equivalent to those obtained by the use of lower sulfur fuel. In addition, a fuel availability relief provision was added for use only by vessels with diesel engines operating on the Great Lakes and the Saint Lawrence Seaway. This provision allowed operators to buy the lowest sulfur marine residual fuel available that met the near-term 1.0% (10,000 parts per million) fuel sulfur standard. Also, existing steamships operating on the Great Lakes and Saint Lawrence Seaway were exempt from the ECA-level fuel sulfur standards in MARPOL Annex VI (U.S. Environmental Protection Agency, 2009).

On July 17, 2009, the International Maritime Organization (IMO) approved in principal a proposal from the United States and Canada to amend MARPOL Annex VI to designate an ECA off the United States and Canadian coasts. The ECA would ensure that ships affecting the U.S. air quality meet stringent nitrogen oxides and fuel sulfur requirements while operating within the designated area, up to 370 kilometers (km) (200 nautical miles) off U.S. coastlines and Hawaii (U.S. Environmental Protection Agency, 2009). California advanced separate regulations and issued a Marine Notice that only distillate fuels can be used within 44.4 km (24 nautical miles) of its shore beginning in July (Oil & Gas Journal, 2009b).

Production

Recovered Elemental Sulfur.—U.S. production statistics were collected on a monthly basis and published in the U.S. Geological Survey (USGS) monthly sulfur Mineral Industry Surveys. All 103 operations to which survey requests were sent responded; this represented 100% of the total production listed in table 1. In 2009, production was 4% lower than that of 2008, and shipments were about 5% lower. After the tremendous price increase for elemental sulfur during 2008 and the subsequent collapse, the value of shipments was 99% less than of that of 2008. Owing to decreased demand for petroleum products, several U.S. petroleum refineries operated at reduced rates. In addition, accidents, technical problems, and weather emergencies at a few refineries limited the amount of sulfur that could be recovered. For 2009, on average, U.S. petroleum refineries operated at 82.8% of capacity and by yearend, at only 80% (North American Sulphur Review, 2010d).

During the 2009 hurricane season, only one tropical storm and one Category 2 hurricane formed within the Gulf of Mexico. The tropical storm passed well east of the oil-and-sulfur-producing region. The hurricane passed directly over the region, but had weakened to a tropical storm by the time it passed over the producing region. Offshore energy producers reported only minor impacts from the Category 2 hurricane, with estimated shut-in production of 2.5 million barrels of crude oil and 322 million cubic meters of natural gas (U.S. Energy Information Administration, 2010b).

Recovered elemental sulfur, which is a nondiscretionary byproduct from petroleum-refining, natural-gas-processing, and coking plants, was produced primarily to comply with environmental regulations that were applicable directly to emissions from the processing facility or indirectly by restricting the sulfur content of the fuels sold or used by the facility. Recovered sulfur was produced by 34 companies at 101 plants in 26 States and 1 plant in the U.S. Virgin Islands. The size of the sulfur recovery operations varied greatly from plants producing more than 500,000 metric tons per year (t/yr) to others producing less than 500 t/yr. Of all the sulfur operations canvassed, 29 produced more than 100,000 metric tons (t) of elemental sulfur in 2009; 15 produced between 50,000 and 100,000 t; 35 produced between 10,000 and 50,000 t; and 23 plants produced less than 10,000 t. By source, 86% of recovered elemental sulfur production came from petroleum refineries or satellite plants that treated refinery gases and coking plants; the remainder was produced at natural-gas-treatment plants (table 3).

The leading producers of recovered sulfur were, all with more than 500,000 t of sulfur production, in descending order of production, Valero Energy Corp., Exxon Mobil Corp., ConocoPhillips Co. (including its joint venture with Encana Corp.), Chevron Corp., Shell Oil Co. (including its joint ventures with Petróleos Mexicanos and Saudi Refining, Inc.), Citgo Petroleum Corp., and BP p.l.c. The 55 plants owned by these companies accounted for 74% of recovered sulfur output during the year. Recovered sulfur production by State and district is listed in tables 2 and 3.

Valero announced that it would permanently close its 210,000-barrels per day Delaware City, DE, refinery. Sulfur production at the site was 80,000 to 90,000 t/yr, some of which was consumed onsite (North America Sulfur Review, 2009a).

In 2009, 6 of the 20 largest oil refineries in the world, in terms of crude processing capacity, were in the United States. In descending order of capacity, they were ExxonMobil's Baytown, TX, and Baton Rouge, LA, refineries; Hovensa L.L.C.'s [Hess Corp.'s joint venture with Petróleos de Venezuela S.A. (PdVSA)] St. Croix, U.S. Virgin Islands refinery; BP's Texas City, TX, refinery; Citgo Petroleum Corp.'s Lake Charles, LA, refinery; and Marathon's Garyville, LA, refinery (Oil & Gas Journal, 2009a). The capacity to process large quantities of crude oil does not necessarily mean that refineries recover large quantities of sulfur, but all these refineries were major producers of recovered sulfur. Sulfur production depends on installed sulfur recovery capacity as well as the types of crude oil that were refined at the specific refineries. Major refineries that process low-sulfur crude oils may have relatively low sulfur production. According to Oil & Gas Journal (2009c, p. 3), the United States operated 20% of world refining capacity, but had almost 40% of sulfur recovery capacity at refineries.

According to data from the National Petrochemical & Refiners Association (2010, p. 1), U.S. refining capacity rose by more than 5% from 2003 through 2009 and by more than 8% from 1999 through 2009, without building any new refineries and with a few small operations closing. In 2009, U.S. refinery capacity was 18 million barrels per day. Although this information did not specifically mention sulfur capacity expansion, any such expansions would likely include increased sulfur recovery facilities, probably proportionally higher than the increases in throughput capacity.

During 2009, new or expansion projects were underway or in the planning stages at 18 refineries in the United States. In addition to increasing throughput capacity at the operations, upgrades were intended to increase the existing refineries' capability to process low-quality, high-sulfur crudes, such as those from Canadian oil sands, Saudi Arabia, and Venezuela. Oil sands producers were partners in some of the projects, as part of a strategy to ensure outlets for future oil sands production. Some new projects were expected to be completed in 2009, but most were expected to be completed between 2010 and 2012 (Sulphur, 2010).

Byproduct Sulfuric Acid.—Sulfuric acid production at copper, lead, molybdenum, and zinc roasters and smelters accounted for about 8% of total domestic production of sulfur in all forms and totaled the equivalent of 749,000 t of elemental sulfur. The portion of total sulfur product represented by byproduct sulfuric acid and the total quantity produced decreased slightly (table 4). Three acid plants operated in conjunction with copper smelters, and three were byproduct operations of lead, molybdenum, and zinc smelting and roasting operations. The three largest byproduct sulfuric acid plants, in terms of size and capacity, were associated with copper smelters.

ıd accounted for 90% of the byproduct sulfuric acid output. he copper producers—Asarco LLC, Kennecott Utah Copper orp., and Freeport McMoRan Copper & Gold Inc.—each perated a sulfuric acid plant at its primary copper smelter.

'onsumption

Apparent domestic consumption of sulfur in all forms was 7% lower than that of 2008 (table 5). Of the sulfur consumed, 3% was obtained from domestic sources as elemental sulfur 76%) and byproduct acid (7%) compared with 69% in 2008, 8% in 2007, 69% in 2006, and 70% in 2005. The remaining 7% was supplied by imports of recovered elemental sulfur 14%) and sulfuric acid (3%). The USGS collected end-use data n sulfur and sulfuric acid according to the standard industrial lassification of industrial activities (table 6).

Sulfur differs from most other major mineral commodities ı that its primary use is as a chemical reagent rather than as a omponent of a finished product. This use generally requires ıat it be converted to an intermediate chemical product rior to its initial use by industry. The leading sulfur end use, ulfuric acid, represented 67% of reported consumption with n identified end use. Although reported as elemental sulfur onsumption in table 6, it is reasonable to assume that nearly ll the sulfur consumption reportedly used in petroleum efining was first converted to sulfuric acid, bringing sulfur sed to produce sulfuric acid to 87% of the total sulfur onsumption. Some identified sulfur end uses were included in ıe "Unidentified" category because these data were proprietary.)ata collected from companies that did not identify shipments y end use also were tabulated as "Unidentified." A significant ortion of the sulfur in the "Unidentified" category may have een shipped to sulfuric acid producers or exported, although lata to support such assumptions were not available.

Because of its desirable properties, sulfuric acid retained its osition as the most universally used mineral acid and the most roduced and consumed inorganic chemical, by volume. Data ased on USGS surveys of sulfur and sulfuric acid producers howed that reported U.S. consumption of sulfur in sulfuric cid (100% basis) increased slightly, and total reported sulfur onsumption decreased by 14%. These reported decreases in onsumption can be attributed to the 15% decrease in agricultural hemicals and 18% decrease in petroleum refining. Reported onsumption figures do not correlate with calculated apparent onsumption owing to reporting errors and possible double ounting in some data categories. These data are considered ndependently from apparent consumption as an indication of narket shares rather than actual consumption totals.

Agriculture was the leading sulfur-consuming industry; onsumption in this end use decreased by 15% to 6.65 Mt ompared with 7.84 Mt in 2008 because of decreased production ɔf other agricultural chemicals. Based on export data reported ɔy the U.S. Census Bureau, the estimated quantity of sulfur needed to manufacture exported phosphatic fertilizers increased by about 4% to 4.5 Mt. More than 50% of domestic fertilizer production typically is exported, as was the case in 2009.

The second ranked end use for sulfur was in petroleum refining and other petroleum and coal products. Producers of sulfur and sulfuric acid reported that the consumption of sulfur in that end use decreased by 18% from that of 2008. Demand for sulfuric acid in copper ore leaching, which was the third ranked end use, decreased by 20%.

The U.S. Census Bureau (2010) also reported that 2.2 Mt of sulfuric acid was produced as a result of recycling spent and contaminated acid from petroleum alkylation and other processes. Two types of companies recycle this material–companies that produce acid for consumption in their own operations and also recycle their own spent acid and companies that provide acid regeneration services to sulfuric acid users. The petroleum refining industry was thought to be the leading source and consumer of recycled acid for use in its alkylation process.

Stocks

Yearend inventories held by recovered elemental sulfur producers increased to 232,000 t, 10% more than those of 2008 (table 1). Based on apparent consumption of all forms of sulfur, combined yearend stocks amounted to about a 9-day supply, compared with a 6-day supply in 2008 and 2007 each, a 7-day supply in 2006, and a 5-day supply in 2005. Final stocks in 2009 represented 4% of the quantity held in inventories at the end of 1976, when sulfur stocks peaked at 5.56 Mt, a 7.4-month supply at that time (Shelton, 1978, p. 1296). When the United States mined large quantities of sulfur, as in 1976, mining companies had the capacity to store large quantities. When mining ceased in 2000, storage capacity declined significantly. Since that time, stocks have been relatively low because recovered sulfur producers have very little room for stocks.

Prices

As mentioned earlier in this report, the low sulfur prices were the big story of the year. Based on total shipments and value reported to the USGS, the average value of shipments for all elemental sulfur was estimated to be $1.73 per metric ton, which was 99% lower than that of 2008. The decreased value reported by producers correlated with the trends in prices recorded in trade publications. In 2009, the lowest average value of shipments was reported, which dates as far back as 1900 for the United States.

The contract prices for elemental sulfur at terminals in Tampa, FL, which are reported weekly in Green Markets, began the year at $136 per ton. In February, prices decreased to $0 per ton. In May, prices increased slightly to $5 per ton and again increased in August to $9 per ton. Prices remained at that level until November, when they increased to $27 per ton. Although the Tampa contract price remained at that level through the end of 2009, price increases were expected in 2010.

Prices vary greatly on a regional basis. Tampa prices were usually the highest reported in the United States because of the large sulfur demand in the central Florida area. During 2009, U.S. West Coast prices varied from less than $0 per ton to $15 per ton. When published prices are less than $0 per ton, expenses are incurred in order to get the material to market. Nearly all the sulfur produced in some regions, such as the West Coast, is processed at forming plants, incurring substantial costs to make solid sulfur in acceptable forms to be shipped overseas.

The majority of West Coast sulfur was shipped overseas. World sulfur prices generally were higher than domestic prices in 2009.

The Abu Dhabi National Oil Co.'s (ADNOC) monthly contract price became the bellwether of sulfur pricing during 2008. Even though prices varied by location, provider, and type, the ADNOC price became a recognized indicator of sulfur price trends. In 2009, the ADNOC contract 2009 price averaged nearly $44 per ton, with the lowest price of $33 per ton in August and the highest price of $57 per ton in December (North America Sulphur Review, 2009b; 2010b).

Foreign Trade

Strong international demand during much of the year resulted in exports from the United States, including the U.S. Virgin Islands, increasing by about 50% in quantity and decreasing by 70% in value compared with those of 2008. The average unit value of export material was $58 per ton, a decrease of 79% from $285 in 2008 (table 7). The leading destination for this material was China, followed, in descending quantity, by Brazil, Mexico, and Canada. Export facilities on the Gulf Coast that began shipping in 2006 have become a significant source for exported sulfur. Exports from the West Coast were 620,000 t, or 44% of total U.S. exports. Exports from the Gulf Coast were 750,000 t, or 53% of the U.S. total.

The United States continued to be a net importer of sulfur. Imports of elemental sulfur exceeded exports by about 275,000 t. Recovered elemental sulfur from Canada, Mexico, and Venezuela delivered to U.S. terminals and consumers in the liquid phase furnished almost 100% of U.S. sulfur import requirements. Total elemental sulfur imports were 43% less in quantity than those of 2008, and lower prices for imported material resulted in the value being about 92% less than that of 2008. Imports from Canada, mostly by rail, were estimated to be 34% lower than those of 2008, waterborne shipments from Mexico were 66% lower, and waterborne imports from Venezuela were estimated to have decreased by 61%. Canada was the source of an estimated 84% of elemental sulfur imports, and Mexico and Venezuela at 7% and 8%, respectively (table 9).

In addition to elemental sulfur, the United States had significant trade in sulfuric acid. Sulfuric acid exports were 3% lower than those of 2008 (table 8). Acid imports were about 5 times greater than exports (tables 8, 10). Canada and Mexico were the sources of 73% of acid imported into the United States, most of which was probably byproduct acid from smelters. Shipments from Canada and some from Mexico came by rail, and the remainder of imports came primarily by ship from Asia and Europe. The tonnage of sulfuric acid imports was about 76% less than that of 2008, and the value of imported sulfuric acid decreased by almost 69%.

World Review

The world sulfur industry remained divided into two sectors—discretionary and nondiscretionary. In the discretionary sector, the mining of sulfur or pyrites is the sole objective; this voluntary production of either sulfur or pyrites (mostly naturally occurring iron sulfide) is based on the orderly mining of discrete deposits, with the objective of obtaining as nearly a complete recovery of the resource as economic conditions permit. In the nondiscretionary sector, sulfur or sulfuric acid is recovered as an involuntary byproduct; the quantity of output is subject to demand for the primary product and environmental regulations that limit atmospheric emissions of sulfur compounds irrespective of sulfur demand. Discretionary sources, once the primary sources of sulfur in all forms, represented 10% of the sulfur produced in all forms worldwide in 2009 (table 11).

Poland was the only country that produced more than 250,000 t of native sulfur by using either the Frasch process or conventional mining methods (table 11). The Frasch process is the term for hot-water mining of native sulfur associated with the caprock of salt domes and in sedimentary deposits; in this mining method, the native sulfur is melted underground with superheated water and brought to the surface by compressed air. The United States, where the Frasch process was developed early in the 20th century, was the leading producer of Frasch sulfur until 2000. Small quantities of native sulfur were produced in Asia, Europe, and South America. The importance of pyrites to the world sulfur supply has significantly decreased; China was the only country of the top producers whose primary sulfur source was pyrites. China produced 87% of world pyrite production.

Of the 25 countries listed in table 11 that produced more than 500,000 t of sulfur, 18 obtained the majority of their production as recovered elemental sulfur. These 25 countries produced 92% of the total sulfur produced worldwide. In 2009, about 29 Mt of elemental sulfur was traded globally. The leading exporters were, in decreasing order of tonnage, Canada, Kazakhstan, Saudi Arabia, Russia, the United States, the United Arab Emirates, Japan, and Iran, all with more than 1 Mt of exports. The leading importer was China, by far, followed by, in decreasing order of tonnage, Morocco, the United States, Tunisia, Brazil, and India. All of the top importing countries had large phosphate fertilizer industries (International Fertilizer Industry Association, 2011).

Supply growth stalled in 2009 as world production was virtually static. Prices generally were stable in the first half of 2009 and showed an increase toward the end of 2009. International prices for 2009 averaged higher than those in the United States. Although actual sulfur production was lower than in 2008, consumption and supply were balanced. Chinese imports were in excess of their average annual consumption.

Native sulfur production, including production of Frasch sulfur at Poland's last operating mine, was about 23% lower than that of 2008. Recovered elemental sulfur production decreased by 4% and byproduct sulfuric acid production decreased slightly compared with those of 2008. For most of 2009, owing to the falling demand in the fertilizer and industrial sectors new sulfur production was limited. However, the lower world production, recovering sulfur consumption, and strong imports from China, created tight market conditions by yearend and continued into 2010. Globally, production of sulfur from pyrites decreased slightly. With lower sulfur prices, pyrites become a less attractive alternative to elemental sulfur for sulfuric acid production. The environmental remediation costs of mining pyrites are more onerous when the price for sulfur is low, as additional costs are incurred when using this less environmentally friendly raw material.

Canada.—Ranked third in the world in sulfur production, Canada was the leading sulfur and sulfuric acid exporter. In 2009, sulfur production in Canada was 8% lower than it was in 2008. About two-thirds of Canadian sulfur is recovered at natural gas and oil sands operations in Alberta, with some recovered from gas in British Columbia and from oil refineries in other parts of the country. Sulfur recovery from natural gas has declined for several years, but increased sulfur production from oil sands offsets that, and this trend was expected to continue. Sulfur production from natural gas processing declined by 13% in 2009, while sulfur production from the oil sands operations continued its upward trend. Production from oil sands was about 15% higher in 2009 than in 2008 (North America Sulphur Review, 2010a).

Canada's sulfur production was expected to remain stable over the medium term and may increase over the long term as a result of expanded oil sands production. Sulfur production from natural gas was expected to decline as natural gas reserves decrease. Significant increases in production from oil sands operations and minor increases at refineries were expected. Canada was likely to remain a leader in world sulfur production. Byproduct acid production was expected to remain relatively stable (Stone, 2010).

Xstrata Plc (Switzerland) announced that it would permanently cease operation at its copper and zinc plants at Kidd Creek, Ontario, in May 2010. The closure would remove a significant volume of merchant sulfuric acid from the North American market. The estimated sulfuric acid production at Kidd Creek was 500,000 t/yr (North America Sulphur Review, 2009a).

A report from Alberta's Energy Resources Conservation Board (ERCB) published in 2010 showed that sulfur emissions in 2009 from Alberta's natural gas processing plants declined by 59% from levels in 2000 and 12% from those of 2008. Sulfur emissions declined as the result of improved sulfur recovery technology at the plants and because gas production had declined as resources have become depleted. Although sulfur recovery increased as a percentage of gas processing, total sulfur recovered declined during the same period because of lower gas processing volumes (Energy Resources Conservation Board, 2010, p. 5).

An estimated 800,000 t of sulfur was added to Canada's stockpiles in 2009. Stocks increased to about 12.3 Mt in Alberta in 2009, more than 8 Mt of which was stored at Syncrude Canada Ltd.'s Fort McMurray, Alberta, oil sands operation. Fort McMurray is so remote that transporting the sulfur to market is extremely difficult and expensive (Stone, 2010).

Oil sands was one of the fastest growing industries in Canada. Expansions at oil sands operations were expected to add an additional 3.6 Mt of sulfur production within 10 years. By 2015, sulfur production from Canadian oil sands was expected to represent 8% of annual world sulfur production (Sulphur, 2007). Continued focus on greenhouse gas emissions from oil sands operations and other environmental scrutiny, however, may limit development of oil sands and direct investment dollars elsewhere. Estimates of the cost of production suggest that a price of $70 per barrel of oil is necessary for oil sands to be profitable. If national and (or) provincial carbon taxes, which have been discussed for Canada and Alberta, were put into place, the cost of oil sands production could become too high. In addition to relatively high carbon dioxide emissions related to oil sands operations compared with those from other petroleum sources, concerns about tailings ponds and land restoration contributed to negative perceptions of oil sands development (Park, 2008).

The Athabasca oil sands are a mixture of sand, water, clay, and bitumen, a naturally occurring viscous mixture of heavy hydrocarbons. Because of its complexity, bitumen was difficult or impossible to refine at most oil refineries. It was upgraded to a light-oil equivalent before further refining or was processed at facilities specifically designed for processing bitumen. Oil sands with more than 10% bitumen were considered rich; those with less than 7% bitumen were not economically attractive (Oil & Gas Journal, 1999). Bitumen contains approximately 5% sulfur. On average, it takes about 1 t of bitumen to produce 1 barrel of oil (Stone, 2007).

In 2009, more elemental sulfur was recovered from Canadian oil sands than in 2008, when the world economic downturn had a negative impact on Canadian oil sands projects. However, oil sands operations require tremendous capital to develop, and only high oil prices allow them to be profitable (Stone, 2010).

The form of the primary product at the oil sands operation influences the quantity of sulfur produced at the oil sands operations or determines whether the sulfur is recovered at refineries at other locations. When the operators process the bitumen from the oil sands into synthetic crude oil, the sulfur is recovered at the upgrading site. If bitumen is transported (usually by pipeline) to oil refineries specially upgraded to process this product, then the sulfur is recovered at the oil refinery, sometimes in other countries, often in the United States (Stone, 2007; 2008).

China.—For the first time, China was the leading producer of sulfur in all forms. It also was the world's leading producer of pyrites, with about 50% of its sulfur in all forms coming from that source. The country was the leading sulfur importer, with 12.5 Mt in 2009 (International Fertilizer Industry Association, 2011). Imports represented 90% of elemental sulfur consumption in China, with the Middle East as the leading source of the imports, followed by Canada. Fertilizer production consumed about three-quarters of the sulfuric acid produced in China.

During the second half of 2008, export tariffs were imposed to keep Chinese phosphates available for farmers in China, but those actions caused shutdowns among fertilizer producers. In July 2009, export tariffs were reduced by 10% in response to the request for a reduction. Fertilizer production was China's primary application for sulfuric acid, and long-term prospects for Chinese fertilizer demand were expected to remain strong. In 2009, strong global imports were driven by heavy purchases of sulfur by China. However, the short-term demand for sulphuric acid was negatively affected by the slump in the fertilizer markets (Sulphur, 2009b).

Without access to the export market, Chinese phosphate producers were only supplying the domestic market rather than increasing revenue by exporting phosphate fertilizer (Sulphur, 2009b). In 2009, China imports averaged about 816,000 metric tons per month of elemental sulfur, with the largest quantities of imports entering the country during the first 6 months of the year (North America Sulphur Review, 2010c). China had sulfur stockpiles of more than 2 months' worth of demand (Sulphur, 2009b).

In China, 70% of electricity is generated at coal-fired powerplants that emit significantly more sulfur dioxide proportionally than powerplants in Western countries. Only about 14% of the Chinese powerplants have desulfurization apparatus, and of these, not all are fully operational. Industry experts estimated that China emitted 25 Mt of sulfur dioxide from powerplants in 2008, with expectations for this to increase as electricity requirements and capacity increased. Sulfur recovery from implementing clean coal technology in China could result in the recovery of at least some of this sulfur, but no timeframe for these accomplishments was proposed (Sulphur, 2008).

The Zinjin Copper Industry Co. (a subsidiary of the Zihn Mining Group Co.) announced plans to build a 200,000-t/yr copper smelting plant in the Fuijan Province. The smelter was expected to produce 700,000 t/yr of sulphuric acid (Sulphur, 2009a).

Kazakhstan.—Kazakstan's largest phosphate producer, Kazphosphate LLC, signed a memorandum of understanding with state company United Chemical Co. (UCC) to build a 650,000-t/yr sulphuric acid complex as part of a major phosphate joint venture at the Karatau phosphate field. The sulphuric acid plant was to be built in Taraz as part of the second phase that was scheduled to begin in 2011. The cost of the two phases of the project was estimated to be nearly $250 million (Sulphur, 2009d).

Outlook

Since 2000, recovered sulfur production in the United States has been relatively stable, averaging about 8.6 million metric tons per year (Mt/yr), but significant increases were expected in upcoming years as expansions, upgrades, and new facilities at existing refineries were completed. The expansions were enabling refiners to increase throughput of crude oil and to process higher sulfur crude oils; additional sulfur production will be a byproduct of refinery upgrades. Projects that had been announced before or during 2009 had the potential to add sulfur recovery capacity of more than 2.8 Mt/yr by 2013, if all were completed on proposed schedules (Sulphur, 2010). In general, production from natural gas operations was expected to remain at about the same level as or increase from that of 2009 as more natural gas is recovered from shale formations, horizontal drilling, and hydraulic fracturing. More efficient, cost-effective drilling techniques, primarily in shale formations, will be important for U.S. natural gas production (U.S. Energy Information Administration, 2010a).

Worldwide recovered sulfur output was expected to increase significantly. In 2009 and 2010, production of sulfur was expected to nearly satisfy demand, but severe sulfur surpluses were expected beginning in 2011, accelerating thereafter as a result of increased production, especially from oil sands in Canada, natural gas in the Middle East, expanded oil and gas operations in Kazakhstan, and heavy-oil processors in Venezuela.

Additional production increases were expected to come from Russia's increase in sulfur recovery from natural gas and Asia's improved sulfur recovery at oil refineries and development of sour gas deposits. Refineries in developing countries were expected to improve environmental protection measures and, in the future, eventually approach the environmental standards of plants in Japan, North America, and Western Europe. Higher sulfur recovery likely will result from a number of factors, including higher refining rates, higher sulfur content in crude oil, lower allowable sulfur content in finished fuels, and reduced sulfur emissions mandated by regulations.

World consumption of natural gas was expected to maintain strong growth, and sulfur recovery from that sector likely will continue to increase. Future gas production, however, is likely to come from deeper, hotter, and more sour deposits that would result in even more excess sulfur production and surpluses, unless more efforts are made to develop new large-scale uses for sulfur. Other alternative technologies for reinjection and long-term storage to eliminate some of the excess sulfur supply will require further investigation to handle the quantity of surplus material anticipated (Hyne, 2000).

Domestic byproduct sulfuric acid production may fluctuate somewhat as the copper industry reacts to market conditions and varying prices by adjusting output at operating smelters. If one of the idled smelters reopened in response to high copper demand and prices, production could increase significantly, but if decreased demand for copper prompted another copper smelter to close, production would decline sharply.

Worldwide, the outlook for byproduct acid was more positive. Because copper production costs in some countries are lower than in the United States, acid production from those countries has increased, and continued increases are likely. Many copper producers have installed more efficient sulfuric acid plants to limit sulfur dioxide emissions at new and existing smelters. Byproduct sulfuric acid production was expected to increase to about 70 Mt in 2014 from about 60 Mt in 2009. Worldwide, sulfur emissions at nonferrous smelters declined as a result of improved sulfur recovery; increased byproduct acid production is likely to become more a function of metal demand than a function of improved recovery technology. One-half of the projected increase of byproduct acid production likely will be from smelters in China, with additional quantities from Chile and Peru, although production from all regions was expected to increase (Sulphur, 2005).

Frasch sulfur and pyrites production, however, has little chance of significant long-term increases. In 2009, Frasch sulfur production decreased by 50%. Because of the continued increase in elemental sulfur recovery for environmental reasons rather than markets, discretionary sulfur has become increasingly less important as demonstrated by the decline of the Frasch sulfur industry. The Frasch process has become the high-cost process for sulfur production. Pyrites, with significant direct production costs, is an even higher cost raw material for sulfuric acid production when the environmental aspects are considered. Discretionary sulfur output is likely to continue a steady decline. The decreases likely will be pronounced when large operations are closed outright for economic reasons, as was the case in 2000 and 2001.

For the long term, sulfur and sulfuric acid likely will continue to be important in agricultural and industrial applications. Because sulfuric acid consumption for phosphate fertilizer production was expected to increase at a lower rate than some other uses, phosphate fertilizer may become less dominant, but is expected to remain the leading end use. Ore leaching likely will be the largest area of sulfur consumption growth.

From year to year, however, the use of sulfur directly or in compounds as fertilizer likely will continue to be dependent on agricultural economies and vary according to economic conditions. If widespread use of plant nutrient sulfur is adopted, then sulfur consumption in that application could increase significantly; thus far, however, growth has been slow. Expansions of phosphate fertilizer production were expected to be constructed in 10 countries, one-half of them in China, with additional facilities planned in Africa, Asia, and Latin America (Heffer and Prud'homme, 2010).

Industrial sulfur consumption has some prospects for growth, but not enough to consume all projected surplus production. Solvent extraction-electrowinning copper projects that consume large quantities of sulfur are under development in Arizona and Utah as well as in Chile, Congo (Kinshasa), Mexico, and Zambia. The total sulfuric acid requirement for these operations could approach 2 Mt/yr of sulfuric acid (Pearson, 2007).

Unless less traditional uses for elemental sulfur increase significantly, the oversupply situation will result in tremendous stockpiles accumulating around the world. In the 1970s and 1980s, research was conducted that showed the effectiveness of sulfur in several construction uses that held the promise of consuming huge quantities of sulfur in sulfur-extended asphalt and sulfur concretes. In many instances, these materials were found to be superior to the more conventional products, but their use so far has been very limited. Concrete made with sulfur is more resistant to acid and saltwater; the manufacturing process lowers CO_2 emissions and does not require water to manufacture (Sulphur, 2009c). However, when sulfur prices are high, sulfur is less attractive for unconventional applications where low-cost raw materials are the important factor.

Although periods of tight supplies may take place periodically, the long-term worldwide oversupply situation is likely to continue. Unless measures are taken to use more sulfur, either voluntarily or through government mandate, large quantities of excess sulfur could be amassed in many areas of the world, including the United States.

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TABLE 1

SALIENT SULFUR STATISTICS[1]

(Thousand metric tons of sulfur content and thousand dollars unless otherwise specified)

		2005	2006	2007	2008	2009
United States:						
Quantity:						
Production:						
Recovered[2]		8,790	8,390	8,280	8,550 r	8,190
Other		711	674	817	753	749
Total[e]		9,500	9,060	9,100	9,300 r	8,940
Shipments:						
Recovered[2]		8,770	8,290	8,310	8,530 r	8,110
Other		711	674	817	753	749
Total		9,480	8,960	9,130	9,280 r	8,860
Exports:						
Elemental[3]		684	635	922	953 r	1,430
Sulfuric acid		110	81 r	110	86	83
Imports:						
Elemental[e]		2,820	2,950	2,930	3,000	1,700
Sulfuric acid		877	802 r	857 r	1,690	413
Consumption, all forms[4]		12,400	12,000	11,900	12,900 r	9,460
Stocks, December 31, producer, recovered		160	221	187	211	232
Value:						
Shipments, free on board (f.o.b.) mine or plant:						
Recovered[e, 2]		270,000	272,000	303,000	2,250,000 r	14,000 e
Other		80,200	64,700	45,200	110,000	234,000
Total		350,000	337,000	349,000	2,360,000 r	248,000
Exports, elemental[5]		55,200	437,000 r	84,800	272,000	82,200
Imports, elemental		70,500	70,400	79,400	753,000	54,100
Price, elemental, f.o.b. mine or plant[e]	dollars per metric ton	30.88	32.85	36.49 r	264.04 r	1.73
World, production, all forms (including pyrites)		68,200 r	67,500 r	68,200 r	68,700 r	67,500

[e] Estimated. [r] Revised.

[1] Data are rounded to no more than three significant digits except prices; may not add to totals shown.

[2] Includes U.S. Virgin Islands.

[3] Includes exports from the U.S. Virgin Islands to foreign countries.

[4] Consumption is calculated as shipments minus exports plus imports.

[5] Includes value of exports from the U.S. Virgin Islands to foreign countries.

TABLE 2
RECOVERED SULFUR PRODUCED AND SHIPPED IN THE UNITED STATES, BY STATE[1]

(Thousand metric tons and thousand dollars)

	2008			2009		
		Shipments			Shipments	
State	Production	Quantity	Value[e]	Production	Quantity	Value[e]
Alabama	285 [r]	281 [r]	94,900	268	264	-4,490
California	1,140	1,110	327,000 [r]	1,010	1,000	4,280
Illinois	458	456	51,700	457	457	-1,160
Louisiana	1,460 [r]	1,470 [r]	399,000 [r]	1,330	1,370	10,300
Michigan and Minnesota	36 [r]	36 [r]	9,410 [r]	35	35	-679
New Mexico	33	33	7,920	25	25	388
Ohio	139	138	44,100	133	133	460
Texas	2,790	2,780	830,000	2,900	2,860	4,450
Washington	136	139	30,800	125	126	-284
Wyoming	745	733	63,200	656	668	3,600
Other[2]	1,330 [r]	1,360 [r]	392,000 [r]	1,250	1,170	-2,880
Total	8,550 [r]	8,530 [r]	2,250,000 [r]	8,190	8,110	14,000

[e] Estimated. [r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes Arkansas, Colorado, Delaware, Florida, Indiana, Kansas, Kentucky, Mississippi, Montana, New Jersey, North Dakota, Pennsylvania, Utah, Virginia, Wisconsin, and the U.S. Virgin Islands.

TABLE 3
RECOVERED SULFUR PRODUCED AND SHIPPED IN THE UNITED STATES, BY PETROLEUM ADMINISTRATION FOR DEFENSE (PAD) DISTRICT[1]

(Thousand metric tons)

	2008		2009	
District and source	Production	Shipments	Production	Shipments
PAD 1:				
Petroleum and coke	243	239	168	166
Natural gas	13	13	13	13
Total	257	252	181	179
PAD 2:				
Petroleum and coke	954	955	945	932
Natural gas	33	33	28	28
Total	987	988	973	960
PAD 3:[2]				
Petroleum and coke	4,650 [r]	4,650 [r]	4,580	4,580
Natural gas	537 [r]	552	546	485
Total	5,180 [r]	5,200 [r]	5,120	5,060
PAD 4 and 5:				
Petroleum and coke	1,400	1,380	1,280	1,270
Natural gas	721	709	627	638
Total	2,120	2,090	1,910	1,910
Grand total	8,550 [r]	8,530 [r]	8,190	8,110
Of which:				
Petroleum and coke	7,240 [r]	7,220 [r]	6,970	6,950
Natural gas	1,300 [r]	1,310	1,220	1,160

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes the U.S. Virgin Islands.

TABLE 4
BYPRODUCT SULFURIC ACID PRODUCED IN THE UNITED STATES[1]

(Thousand metric tons of sulfur content and thousand dollars)

Type of plant	2008	2009
Copper[2]	655	671
Zinc, lead, and molybdenum[3]	98	79
Total:		
Quantity	753	749
Value	110,000	234,000

[1] May include acid produced from imported raw materials. Data are rounded to no more than three significant digits, may not add to totals shown.

[2] Excludes acid made from pyrites concentrates.

[3] Excludes acid made from native sulfur.

TABLE 5
CONSUMPTION OF SULFUR IN THE UNITED STATES[1]

(Thousand metric tons)

	2008	2009
Elemental sulfur:		
Shipments[2]	8,530 r	8,110
Exports	953 r	1,430
Imports[e]	3,000	1,700
Total	10,600 r	8,380
Byproduct sulfuric acid:		
Shipments	753	749
Exports[3]	86	83
Imports[3]	1,690	413
Total	2,360	1,080
Grand total	12,900	9,460

[e] Estimated. [r] Revised.

[1] Crude sulfur or sulfur content. Data are rounded to no more than three significant digits; may not add to totals shown. Consumption is calculated as shipments minus exports plus imports.

[2] Includes the U.S. Virgin Islands.

[3] May include sulfuric acid other than byproduct.

TABLE 6
SULFUR AND SULFURIC ACID SOLD OR USED IN THE UNITED STATES, BY END USE[1]

(Thousand metric tons of sulfur content)

SIC[3]	End use	Elemental sulfur[2] 2008	Elemental sulfur[2] 2009	Sulfuric acid (sulfur equivalent) 2008	Sulfuric acid (sulfur equivalent) 2009	Total 2008	Total 2009
102	Copper ores	--	--	456	363	456	363
1094	Uranium and vanadium ores	--	--	3	2	3	2
10	Other ores	--	--	121	112	121	112
26, 261	Pulpmills and paper products	W	W	187	188	187	188
28, 285, 286, 2816	Inorganic pigments, paints, and allied products; industrial organic chemicals, other chemical products[4]	W	W	293	286	293	286
281	Other inorganic chemicals	49	1	38	99	87	100
282, 2822	Synthetic rubber and other plastic materials and synthetics	W	W	69	64	69	64
2823	Cellulosic fibers including rayon	--	--	31	7	31	7
284	Soaps and detergents	W	W	3	3	3	3
286	Industrial organic chemicals	--	--	177	36	177	36
2873	Nitrogenous fertilizers	--	--	58	161	58	161
2874	Phosphatic fertilizers	--	--	5,690	5,430	5,690	5,430
2879	Pesticides	--	--	15	9	15	9
287	Other agricultural chemicals	2,050	1,000	28	44	2,080	1,050
2892	Explosives	--	--	10	10	10	10
2899	Water-treating compounds	--	--	48	64	48	64
28	Other chemical products	--	--	34	250	34	250
29, 291	Petroleum refining and other petroleum and coal products	2,990	2,360	244	283	3,230	2,650
331	Steel pickling	--	--	6	8	6	8
333	Nonferrous metals	--	--	1	--	1	--
33	Other primary metals	--	--	5	5	5	5
3691	Storage batteries (acid)	--	--	24	28	24	28
	Exported sulfuric acid	--	--	7	197	7	197
	Total identified	5,090	3,370	7,540	7,650	12,600 [r]	11,000
	Unidentified	684	489	132	91	816	585
	Grand total	5,770	3,860	7,680	7,740	13,400 [r]	11,600

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Unidentified." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Does not include elemental sulfur used for production of sulfuric acid.

[3] Standard industrial classification.

[4] No elemental sulfur was used in inorganic pigments, paints, and allied products.

TABLE 7

U.S. EXPORTS OF ELEMENTAL SULFUR, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

Country	2008		2009	
	Quantity	Value	Quantity	Value
Brazil	184	68,800	383	15,600
Canada	102	51,100	29	5,730
China	358	51,100	731	39,800
Mexico	102	43,000	127	8,030
Morocco	27	1,660	33	1,610
Other	180 r	55,800 r	122	11,400
Total	953	272,000	1,430	82,200

r Revised.

[1] Includes exports from the U.S. Virgin Islands. Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 8

U.S. EXPORTS OF SULFURIC ACID (100% H_2SO_4), BY COUNTRY[1]

Country	2008		2009	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Canada	160,000	$11,900	212,000	$14,300
Chile	10,700	2,840	--	--
China	1,740	369	2,750	371
Dominican Republic	4,580	539	649	149
El Salvador	10	20	469	74
Germany	16	43	494	102
Greece	662	82	505	60
Hong Kong	710	178	21	57
Ireland	1,430	1,330	1,180	1,500
Israel	604	771	2,680	2,340
Jamaica	5,930	1,710	--	--
Korea, Republic of	461	79	79	30
Mexico	14,400	3,820	3,810	1,150
Netherlands Antilles	5,780	1,750	3,040	539
Nigeria	1,300	152	1	9
Phillipines	92	128	469	313
Poland	139	335	825	94
Singapore	53	68	66	143
Sri Lanka	1,150	132	--	--
Taiwan	113	179	843	205
Thailand	44	40	463	95
Trinidad and Tobago	14,600	3,620	4,760	543
Venezuela	33,900	11,100	16,400	1,070
Other	3,400 r	1,450 r	2,230	767
Total	262,000	42,700	254,000	23,900

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 9

U.S. IMPORTS OF ELEMENTAL SULFUR, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2008		2009	
Country	Quantity	Value[2]	Quantity	Value[2]
Canada	2,180	415,000	1,430 e	45,800
Mexico	366 r	140,000	125	2,540
Venezuela	360	134,000	140 e	2,400
Other	98	64,600	6	3,390
Total	3,000	753,000	1,700 e	54,100

eEstimated. rRevised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Declared customs valuation.

Source: U.S. Census Bureau and PentaSul North American Sulphur Service as adjusted by the U.S. Geological Survey.

TABLE 10

U.S. IMPORTS OF SULFURIC ACID (100% H_2SO_4), BY COUNTRY[1]

	2008		2009	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Bulgaria	26,800	$7,260	29,100	$481
Canada	2,350,000	233,000	821,000	118,000
China	109,000	30,100	392	386
Egypt	26,800	7,950	--	--
Finland	23,000	3,600	39,300	4,040
India	2,070,000 r	60,500	--	--
Japan	65,900	14,600	20,000	477
Korea, Republic of	12,100	1,200	37,000	4,160
Mexico	297,000	55,700	108,000	4,750
Peru	55,800	15,400	66,700	2,300
Poland	26,700	4,360	30,200	434
Sweden	25,000	6,110	15,600	742
Other	94,800 r	28,400 r	98,200	10,300
Total	5,180,000 r	468,000 r	1,260,000	146,000

rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Declared cost, insurance, and freight paid by shipper valuation.

Source: U.S. Census Bureau.

TABLE 11

SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY AND SOURCE[1, 2]

(Thousand metric tons)

Country and source[3]	2005	2006	2007	2008	2009
Australia, byproduct:[e]					
Metallurgy	880	880	890	880	870
Petroleum	60	58	58 [r]	60 [r]	60
Total	940	938	948 [r]	940 [r]	930
Brazil:					
Frasch	20	21	22	22 [e]	22 [e]
Byproduct:					
Metallurgy	267	298	322	322	322 [p]
Petroleum	112	117	136	136	136 [p]
Total	399	436	480	480	480
Canada, byproduct:					
Metallurgy	1,058 [r]	1,176	1,167	1,148 [r]	890
Natural gas, petroleum, oil sands	7,915	7,906	7,622	7,008 [r]	6,577
Total	8,973 [r]	9,082	8,789	8,156 [r]	7,467
Chile, byproduct, metallurgy	1,635	1,641	1,569	1,573	1,627
China:[e]					
Elemental	900	950	960	960	1,000
Pyrites	4,010	3,810	4,200	4,300	4,370
Byproduct, metallurgy	2,800	3,000	3,300	3,350	4,000
Total	7,710	7,760	8,460	8,610	9,370
Finland:[e]					
Pyrites	270	250	250	250	250
Byproduct:					
Metallurgy	300	300	300	300	300
Petroleum	70	70 [r]	70 [r]	70 [r]	70
Total	640	620 [r]	620 [r]	620 [r]	620
France, byproduct, all sources[e]	616 [r]	650 [r]	650 [r]	650 [r]	650
Germany, byproduct:					
Metallurgy	2,292 [r]	2,437 [r]	2,454 [r]	2,458 [r]	2,137
Natural gas and petroleum	1,585	1,686	1,637	1,709	1,623
Total	3,877 [r]	4,123 [r]	4,091 [r]	4,167 [r]	3,760
India:[e]					
Pyrites	32	32	32	32	32
Byproduct:					
Metallurgy	580	600	590	600	590
Natural gas and petroleum	520	540	530	540	530
Total	1,130	1,170	1,150	1,170	1,150
Iran, byproduct:[e]					
Metallurgy	60	60 [r]	70	70	70
Natural gas and petroleum	1,400	1,400	1,500	1,500	1,500
Total	1,460	1,460 [r]	1,570	1,570	1,570
Italy, byproduct:[e]					
Metallurgy	92	90	90	90	90
Petroleum	650	650	650	650	650
Total	742	740	740	740	740
Japan, byproduct:					
Metallurgy	1,284	1,343	1,250	1,300 [e]	1,350 [e]
Petroleum	1,972	1,950	1,966	2,034 [r]	1,864
Total	3,256	3,293	3,216	3,334 [r]	3,214

See footnotes at end of table.

TABLE 11—Continued

SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY AND SOURCE[1, 2]

(Thousand metric tons)

Country and source[3]	2005	2006	2007	2008	2009
Kazakhstan, byproduct:[e]					
Metallurgy	325	300	300	300	300
Natural gas and petroleum	1,700	1,700	1,661 [4]	1,733 [4]	1,700
Total	2,025	2,000	1,960	2,030	2,000
Korea, Republic of, byproduct:[e]					
Metallurgy	800 [r]	660 [r]	670 [r]	660 [r]	600
Petroleum	900 [r]	950	1,000 [r]	900 [r]	900
Total	1,700	1,610 [r]	1,670 [r]	1,560 [r]	1,500
Kuwait, byproduct, natural gas and petroleum[e]	836 [r]	742 [r]	830 [r]	830 [r]	830
Mexico, byproduct:					
Metallurgy[e]	750	650	550	700	700
Natural gas and petroleum	1,017	1,074	1,026	1,041	1,000 [e]
Total	1,767	1,724	1,576	1,741	1,700 [e]
Netherlands, byproduct:[e]					
Metallurgy	141 [r]	111 [r]	115 [r]	115 [r]	115
Petroleum	400	400	400	400	400
Total	541 [r]	511 [r]	515 [r]	515 [r]	515
Poland:[e, 5]					
Native	802	800	834	762	263
Byproduct:					
Metallurgy	292	307	304	294 [r]	260
Natural gas	21	20	23 [r]	21	21
Petroleum	164	182	188	201 [r]	180
Other	2	2	2	3	3
Total	1,280	1,310	1,350	1,280	727
Russia:[e, 6]					
Native	50	50	50	50	50
Pyrites	300	200	200	200	200
Byproduct:					
Metallurgy	600	700	800	820	820
Natural gas	6,000	6,000	6,000	6,100	6,000
Total	6,950	6,950	7,050	7,170	7,070
Saudi Arabia, byproduct, all sources	2,717	2,907	3,089	3,163	3,214
South Africa:					
Pyrites, S content, from gold mines	133	68	71	61	60
Byproduct:					
Metallurgy, copper, platinum, zinc plants	220	231	236	187 [r]	176 [e]
Petroleum	422	343	335	323 [r]	303 [e]
Total	776	643	642	571 [r]	539 [e]
Spain, byproduct:[e]					
Coal, lignite, gasification	1	1	1	1	1
Metallurgy	500	500	500	500	500
Petroleum[6]	112 [r]	117 [r]	136 [r]	136 [r]	136 [p]
Total	613 [r]	618 [r]	637 [r]	637 [r]	637
United Arab Emirates, byproduct, natural gas and petroleum[e]	1,950	1,950	1,950	2,175 [r, 4]	2,175 [4]
United States, byproduct:					
Metallurgy	711	674	817	753	749
Natural gas	1,850	1,430	1,280	1,300 [r]	1,220
Petroleum	6,940	6,960	7,000	7,240 [r]	6,970
Total	9,500	9,060	9,100	9,300 [r]	8,940

See footnotes at end of table.

TABLE 11—Continued
SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY AND SOURCE[1, 2]

(Thousand metric tons)

Country and source[3]	2005	2006	2007	2008	2009
Uzbekistan, byproduct:[e]					
Metallurgy	170	170	170	170	170
Natural gas and petroleum	350	350	350	350	350
Total	520	520	520	520	520
Venezuela, byproduct, natural gas and petroleum[e]	800	800	800	800	800
Other[e]	4,870 [r]	4,230 [r]	4,250 [r]	4,410 [r]	4,760
Of which:					
Frasch	-- [r]	-- [r]	-- [r]	-- [r]	--
Native[7]	236	201	200	206 [r]	207
Pyrites	161	155	150	153	130
Unspecified	1,380	1,150	1,140	1,150 [r]	1,190
Byproduct:					
Metallurgy	1,020 [r]	1,040 [r]	1,050 [r]	1,050 [r]	1,050
Natural gas	361	361	361	528 [r]	659
Natural gas and petroleum, undifferentiated	475 [r]	481 [r]	472 [r]	428 [r]	722
Petroleum	1,230 [r]	833 [r]	875 [r]	898 [r]	810
Grand total	68,200 [r]	67,500 [r]	68,200 [r]	68,700 [r]	67,500
Of which:					
Frasch	20 [r]	21 [r]	22 [r]	22 [r]	22
Native[8]	1,990 [r]	2,000 [r]	2,040 [r]	1,980 [r]	1,520
Pyrites	4,910	4,520	4,900	5,000	5,040
Unspecified	4,710	4,710	4,880	4,960	5,050
Byproduct:					
Coal, lignite, gasification[e]	1	1	1	1	1
Metallurgy	16,800 [r]	17,200 [r]	17,500 [r]	17,600 [r]	17,700
Natural gas	8,230	7,810	7,670	7,950 [r]	7,900
Natural gas, petroleum, oil sands, undifferentiated	18,500 [r]	18,600 [r]	18,400 [r]	18,100 [r]	17,800
Petroleum	13,000	12,600 [r]	12,800 [r]	13,100 [r]	12,500

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 28, 2010.

[3] The term "source" reflects the means of collecting sulfur and the type of raw material. Sources listed include the following: Frasch recovery; native comprising all production of elemental sulfur by traditional mining methods (thereby excluding Frasch); pyrites (whether or not the sulfur is recovered in the elemental form or as acid); byproduct recovery, either as elemental sulfur or as sulfur compounds from coal gasification, metallurgical operations including associated coal processing, crude oil and natural gas extraction, petroleum refining, oil sand cleaning, and processing of spent oxide from stack-gas scrubbers; and recovery from processing mined gypsum. Recovery of sulfur in the form of sulfuric acid from artificial gypsum produced as a byproduct of phosphatic fertilizer production is excluded, because to include it would result in double counting. Production of Frasch sulfur, other native sulfur, pyrite-derived sulfur, mined gypsum derived sulfur, byproduct sulfur from extraction of crude oil and natural gas, and recovery from oil sands are all credited to the country of origin of the extracted raw materials. In contrast, byproduct recovery from metallurgical operations, petroleum refineries, and spent oxides are credited to the nation where the recovery takes place, which is not the original source country of the crude product from which the sulfur is extracted.

[4] Reported figure.

[5] Government of Poland sources report total Frasch and native mined elemental sulfur output annually, undifferentiated.

[6] Sulfur is thought to be produced from Frasch and as a petroleum byproduct; however, information is inadequate to formulate estimates.

[7] Excludes "China, elemental" and "Russia, native."

[8] Includes "China, elemental" and "Russia, native."

TALC AND PYROPHYLLITE

By Robert L. Virta

Domestic survey data and tables were prepared by Robin C. Kaiser, statistical assistant, and the world production table was epared by Glenn J. Wallace, international data coordinator.

In 2009, talc production decreased to 511,000 metric tons (t) lued at $14.6 million from 706,000 t valued at $21.8 million 2008. Sales of talc decreased to 512,000 t valued at $57.2 illion from 667,000 t valued at $83.3 million in 2008. U.S. parent consumption decreased to 443,000 t in 2009 from 5,000 t in 2008. Exports of talc decreased to 188,000 t in 09 from 244,000 t in 2008, and imports decreased to 120,000 n 2009 from 193,000 t in 2008. U.S. production and sales of rophyllite decreased slightly in 2009 (data are withheld to oid disclosing proprietary information). World production of c and pyrophyllite declined to 7.43 million metric tons (Mt) in 09 from 7.58 Mt in 2008. The decline in the world economies, ich began in early 2008, resulted in reduced sales to most of e industries on which talc is dependent.

egislation and Government Programs

In 2009, the U.S. Department of Defense authorized the sposal of 865 t of block and lump talc and 621 t of ground lc, the entire uncommitted inventory of the National Defense ockpile (NDS). There were no sales from the NDS in 2009.

roduction

Talc.—Domestic production data were obtained through a luntary survey of U.S. mining companies conducted by the .S. Geological Survey (USGS). Survey forms were sent to x companies that mined talc, and responses were received om four companies. Responses accounted for about 99% the production data presented in table 1. Data for the nrespondents were estimated from preliminary reported data ised on 9 months of production in 2009, reported prior-year ita adjusted according to employment and consuming industry ends, and Mine Safety and Health Administration employment ita.

In 2009, three companies operating six mines in three States ined talc. All were open pit mining operations. The producers ere, in decreasing order of production, Luzenac Group (a vision of Rio Tinto plc) in Montana and Vermont, American ilc Co. in Texas, and Specialty Minerals Inc. (a subsidiary of linerals Technologies Inc.) in Montana. Alberene Soapstone o. in Virginia, and CAL-TALC, Inc. and Protech Minerals Inc., th in California, worked from stockpiles in 2009. The three ading domestic producers collectively accounted for more than 9% of the U.S. tonnage mined.

U.S. mine production decreased to 511,000 t valued at $14.6 illion compared with 706,000 t valued at $21.8 million in 008 (table 1). The large decline in production from 2008 to 009 resulted for two reasons. First, a major talc producer in ew York closed its mine in 2008, reducing the production ipacity of the U.S. talc industry significantly. Second, the world economic recession continued to have a major negative impact on U.S. talc production because of the continued low level of activity of the U.S. markets that the talc producers serve and reduced foreign markets for U.S. exports. In 2009, the three major talc producers reduced mine output and three small producers only worked from stocks. Output decreased in all producing States. Montana led all States in the tonnage of talc produced, followed by Texas and Vermont.

R.T. Vanderbilt Co., Inc. completely exited the talc market in mid-2009. The company, which stopped mining talc in 2008, was filling customer orders from stocks. The company cited decreased sales to the ceramic and paint markets as the main reason for the closure of its mine in New York (Ellen, 2009; Watertown Daily Times, 2009). R.T. Vanderbilt was one of the top four U.S. talc producers since it entered the talc market in the early 1970s and New York was the lead producing State for most of the time between 1900 and 1974.

Pyrophyllite.—Domestic production data of pyrophyllite (a hydrous aluminum silicate with a structure similar to talc) were acquired through a voluntary USGS survey of the two U.S. companies. Both companies responded to the survey.

Standard Mineral Co. operated two mines in North Carolina and Standard Industrial Minerals, Inc. operated one mine in California. Similar to talc, the pyrophyllite industry was negatively affected by the U.S. economic recession, with U.S. production decreasing in 2009 from that of 2008. Domestic data were withheld to avoid revealing company proprietary data.

Consumption

Domestic consumption data for talc and pyrophyllite were developed by the USGS from a voluntary survey of U.S. mills. Survey forms were sent to 9 companies operating 10 mills in 6 States for talc and 2 companies operating 2 mills in 2 States for pyrophyllite. Responses from six companies accounted for more than 99% of the talc data presented in table 2. The remaining data were estimated from preliminary data based on 9 months of production in 2009, reported prior-year data adjusted according to employment and consuming industry trends, and Mine Safety and Health Administration employment data.

Talc.—Sales and use were 512,000 t of talc valued at $57.2 million in 2009, a decrease from 667,000 t valued at $83.3 million in 2008 (table 1). U.S. producers reported that talc sold domestically and not exported decreased to 421,000 t in 2009 from 536,000 t in 2008. Ceramics (mainly ceramic tiles) were the leading market, followed by paint, paper, plastics, roofing, cosmetics, and rubber, in decreasing order of consumption (table 2). Sales to the domestic cosmetics industry increased slightly and sales to other markets decreased in 2009. The largest declines, by tonnage, were in sales to paint and paper markets. Most of the decline in paint sales was attributed to lower demand for paint by the construction and manufacturing industries. There was a lower demand for paper products in North America in 2009 (Pulp and Paper Network, LLC, 2009). This reduced paper demand had a significant negative impact on sales of talc, which was used mainly for pitch control, to the paper industry. A decrease in U.S. manufacturing in 2009 resulted in a decline in talc sales to other talc markets.

Sales of talc to manufacturers of ceramics (mainly tile), paint, and roofing were tied to commercial and home construction and renovation. Construction starts for new privately owned housing decreased to 555,000 units in 2009 from 905,000 units in 2008 (U.S. Census Bureau, 2010b). The value of all construction (residential and commercial) decreased to $937 billion in 2009 from $1.07 trillion in 2008 (U.S. Census Bureau, 2010a).

Shipments of architectural paint (a major paint market for talc) decreased to 2.21 billion liters (585 million gallons) in 2009 from 2.57 billion liters (679 million gallons) in 2008 (U.S. Census Bureau, 2010c). Ceramic tile is a major market for talc. U.S. producers sell their talc to domestic tile manufacturers, whose tile competes with imported ceramic tile. The U.S. International Trade Commission (undated) reported that imports of ceramic tile under Harmonized Tariff Schedule of the United States (HTS) codes 6907.10.00, 6908.10.10, 6908.10.20, and 6908.10.50 decreased in quantity to 6.95 million square meters valued at $68.6 million in 2009 from 10.8 million square meters valued at $108 million in 2008. The decrease in imports was associated with decreased commercial and residential construction.

Most of the 120,000 t of imported talc listed in table 5 was not included in the domestic end-use data listed in table 2. An estimated end-use breakdown of sales of imports in 2009 is plastics, 89,000 t; cosmetics, 15,000 t; paint, 8,000 t; ceramics and refractory products, 3,000 t; paper, 2,000 t; rubber, 1,000 t; and other (unspecified), 2,000 t. Combining domestic sales by U.S. producers (table 2) with sales of imported talc, markets in the United States were, in decreasing order of consumption, plastics, ceramics, paint, paper, cosmetics, roofing, and rubber.

Mineral Technologies, the parent company for Specialty Minerals, reported talc sales of $32.3 million, a 10% decline in value from $35.9 million in 2008. Reduced sales took place in automotive and commercial and residential construction markets (Minerals Technologies Inc., 2010a, p. 20–21). Specialty Minerals operated a talc mine and mill near Barrett, MT.

Pyrophyllite.—In 2009, domestic consumption of pyrophyllite decreased slightly from that of 2008; data are withheld to avoid disclosing company proprietary data. Pyrophyllite was used in refractory products, paint, ceramics, and unspecified applications, in decreasing order of consumption. Refractory uses accounted for more than 50% of domestic pyrophyllite sales.

Prices

In 2009, the unit value of crude talc was estimated to be $29 per metric ton compared with $31 per ton in 2008. Nearly all talc sold in the United States was sold only after crushing and grinding. Following sorting to remove waste, primary crushing, and screening, the unit value of the unmilled talc would likely range from $50 to $60 per ton. The average reported unit value of processed talc was $111 per ton in 2009, a decrease from the unit value of $125 per ton in 2008. The lower unit value in 2009 resulted largely because of declines in sales to higher value talc markets, such as paints, paper, and plastics. The unit values of crude and processed pyrophyllite were essentially unchanged in 2009.

The average free alongside ship unit value of all exports increased to $200 per ton in 2009 from $189 per ton in 2008 (table 4). The unit value for milled talc (HTS code 2526.20.00.00) exports decreased to $199 per ton in 2009 from $211 per ton in 2008. Reduced world talc demand resulted in excess world capacity and pressure on producers to reduce prices for large volume talc purchases in 2009. The average free alongside ship unit value for exports of unmilled talc (HTS code 2526.10.00.00) increased to $460 per ton in 2009 from $327 per ton in 2008. The unit value of unmilled talc increased significantly because there were more high-value, low-tonnage exports in 2009 compared with those of 2008. The greater value of unmilled talc exports compared with milled talc exports is likely owing to the inclusion of more high-value specialty talc grades in unmilled talc exports.

The average Customs unit value for all talc imports was $400 per ton in 2009 compared with $292 per ton in 2008. The average unit value for imports of unground talc (HTS code 2526.10.00.00) was $287 per ton in 2009, an increase from $207 per ton in 2008, the result of higher valued unmilled talc imported from Brazil and Canada. The average customs value for ground talc (HTS code 2526.20.00.00) was $314 per ton in 2009, an increase from $262 per ton in 2008. Higher value imports from Canada and small but very high-valued shipments from several other countries caused the increase in value. The average customs value for cut or sawed talc (HTS code 6815.99.20.00) was $1,079 per ton, an increase from $1,04[illegible] ton in 2008 (table 5).

Published prices for talc ranged from $92 to $245 per ton (table 3). Prices for pyrophyllite from the Republic of Korea, free on board, were $166 per ton for fiberglass and refractory manufacturing, $27 to $44 per ton for ceramic grade, and $1[illegible] to $150 per ton for filler grade. The price for filler grades from Australia was $342 per ton (Industrial Minerals, 2009d). Quoted prices should be used only as a guideline because actual prices depend on the contract terms between seller and buyer.

Foreign Trade

The following section summarizes significant trade statistics on talc. Detailed statistics, by country and U.S. port districts, are available from the U.S. International Trade Commission on its Interactive Tariff and Trade Dataweb Website (U.S. International Trade Commission, undated). In general, trade in talc declined in 2009 compared with that in 2008 because of the world economic recession. U.S. talc exports decreased in tonnage to 188,000 t valued at $37.6 million in 2009 from 244,000 t valued at $46.0 million in 2008. By tonnage, Mexico was the leading importer of talc from the United States, followed by Canada (table 4). These two countries accounted for 64% of U.S. exports. About 94% of talc exports were milled.

U.S. talc imports decreased to 120,000 t valued at $4[illegible] million in 2009 from 193,000 t valued at $56.4 million in [illegible] decrease in talc imports from China and Canada accounted for ost of the decline in U.S. imports in 2009. By tonnage, China as the leading source for imported talc, followed closely by anada (table 5). Imports from Japan were likely pyrophyllite ther than talc.

orld Review

World production of talc and pyrophyllite was estimated to be 43 Mt in 2009, a decrease from the 7.58 Mt produced in 2008. hina was the world's leading producer of talc, followed by the nited States, India, Finland, and France (crude). The Republic Korea was the leading producer of pyrophyllite, followed by pan and Brazil. Brazil, China, Finland, France, India, Japan, e Republic of Korea, and the United States together produced % of the world's talc and pyrophyllite (table 6).

Rio Tinto (the parent company for Rio Tinto Minerals) layed the sale of its worldwide talc division, which had been the market since 2007. The company indicated that poor onomic conditions worldwide resulted in an undervaluing their talc assets. Rio Tinto indicated that 2009 world sales, hich were 888,000 t, declined 24% relative to 2008. Sales, wever, increased 18% in the fourth quarter of 2009 compared ith those of the same period in 2008 because of a slight covery in European markets (Industrial Minerals, 2009e; Rio nto, 2010b, p. 6, 8). Rio Tinto Minerals, through its Luzenac orth America division, was the leading U.S. talc producer, th mines in Montana and Vermont. Rio Tinto Minerals also d talc mines and mills in Australia, Austria, France, Italy, and ain.

Canada.—Globex Engineering Enterprises Inc. continued its ork on a magnesite and talc deposit near Timmins, Ontario. eliminary testing suggested the talc was suitable for such arkets as cosmetics, paper, and plastics (Industrial Minerals, 09e).

China.—Mondo Minerals B.V., Europe's leading world oducer of talc, entered into a joint venture with Chinese oducer Beihai Group to mine talc in Liaoning Province, ina. The venture allowed the company to access high-quality c reserves in China and reduced its dependence on talc from Finnish operation and other sources. Mondo Minerals also de this move because many of its customers were relocating Asia, where markets were expanding (Industrial Minerals, 09a).

India.—Golcha Associated Group, one of India's leading talc oducers, increased production to 234,000 t in the 2008–09 cal year compared with 160,000 t in the 2007–08 fiscal year. India, considerable growth in the paper, plastics, and paint ustries in the past 4 to 5 years contributed to opportunities to pand talc sales (Industrial Minerals, 2009c).

Slovokia.—Mondo Minerals agreed to purchase at least ,000 metric tons per year (t/yr) for 10 years from Rozmin .o. Mondo Minerals also had the option to extend its purchase reement for another 10 years and had the first right of refusal EuroGas GmbH, the major partner in Rozmin, decided to l its 51% interest in Rozmin. Rozmin planned to develop alc deposit near Gemerska Poloma in eastern Slovakia, th production expected to begin in 2010. Ownership of the Gemerska Poloma deposit continued to be disputed by VSK Mining s.r.o. (Industrial Minerals, 2009b).

Thailand.—Golcha Group, India's leading talc producer, opened a new talc mill in Thailand. The 36,000-t/yr plant, operated by M/S Golcha-Chemintac Co. Ltd. Thailand processed Indian ore for ceramic, cosmetics, detergent, paint, paper, pharmaceutical, plastic, and soap markets in Southeast Asia (Industrial Minerals, 2009a).

Outlook

The worldwide economic recession continued to affect the global talc industry in 2009. Major market sectors, such as automotive, housing, and general manufacturing, declined in 2008 and made no significant recovery through most of 2009. This affected talc sales for such product applications as adhesives, caulks, ceramics, joint compounds, paint, plastics, roofing, and rubber.

U.S. industrial output and construction both appeared to slightly increase in early 2010 and hinted at the beginnings of an economic recovery. Economic growth was expected to be greatest in countries with developing and emerging economies, averaging 6% in 2010 and about 8% in 2011. The economies of other countries, particularly in Europe and North America, were expected to increase at a slower pace, averaging 2% in 2010 and 2.5% in 2011 (International Monetary Fund, 2010). Rio Tinto and Minerals Technologies reported production and sales of talc increased more than 19% in tonnage and 55% in value, respectively, in the first quarter of 2010 compared with that of the first quarter of 2009 (Minerals Technologies Inc., 2010b; Rio Tinto plc, 2010a). These increases in the first quarter of 2010 suggested that U.S. talc production and sales may rebound 7% or 8% in 2010. Although the increase may be significant, U.S. production, sales, and apparent consumption still may be considerably below those of 2006, before the recession began affecting the talc industry. Slightly greater growth may take place in 2011 if the economy continues to recover. Similar growth patterns may also be seen with pyrophyllite, as a slow recovery begins in major industries that use pyrophyllite to produce ceramic, paint, and refractory products.

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TABLE 1
SALIENT TALC AND PYROPHYLLITE STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2005	2006	2007	2008	2009
United States:					
Mine production, crude:					
Quantity:					
Talc	856	895	769	706	511
Pyrophyllite	W	W	W	W	W
Value:					
Talc	24,400	27,400	24,400	21,800	14,600
Pyrophyllite	W	W	W	W	W
Sold by producers, crude and processed:					
Quantity:					
Talc	826	900	720	667	512
Pyrophyllite	W	W	W	W	W
Value:					
Talc	71,300	81,300	82,000	83,300	57,200
Pyrophyllite	W	W	W	W	W
Exports, talc:[2]					
Quantity	270	253	271	244	188
Value	45,000	46,800	50,600	46,000	37,600
Imports for consumption, talc:					
Quantity	237	314	221	193	120
Value	55,600	66,700	64,100	56,400	47,900
Apparent consumption[3]	823	956	719	655	443
World, production	7,950 r	7,770 r	7,700 r	7,580 r	7,430

r Revised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes powder—talcum (in package), face, and compact.

[3] Production plus imports minus exports plus adjustments in Government and industry stocks. Does not include pyrophyllite.

TABLE 2
END USES FOR TALC
PRODUCED IN THE UNITED STATES[1]

(Thousand metric tons)

	2008	2009
Ceramics[2]	109	95
Cosmetics	14	16
Paint	124	81
Paper	100	81
Plastics	43	39
Roofing	49	31
Rubber	17	14
Other[3]	80	65
Total	536	421

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes tile.

[3] Includes art sculpture, asphalt filler, auto body filler, construction caulks, flooring, insecticides, joint compound, and other uses not specified.

TABLE 3
PRICES OF TALC

(Dollars per metric ton)

	Price
New York:	
Paint-grade:	
200 mesh	126
400 mesh	210
Ceramic-grade:	
200 mesh	92
325 mesh	115
Indian, cosmetic-grade	190–195
Chinese, normal (ex-store United Kingdom):	
200 mesh	215–235
350 mesh	220–245

Source: Industrial Minerals, March 2009.

TABLE 4
U.S. EXPORTS OF TALC[1, 2]

(Thousand metric tons and thousand dollars)

	2008		2009	
Country	Quantity	Value[3]	Quantity	Value[3]
Belgium	3	1,860	--	--
Canada[4]	69	12,400	54	10,400
Germany	1	118	--	--
Japan	4	1,110	5	743
Mexico	75	7,840	67	6,850
Singapore	4	1,520	3	1,170
Other[5]	88	21,200	59	18,400
Total	244	46,000	188	37,600

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes powders—talcum (in package), face, and compact.

[3] Free alongside ship.

[4] Probably includes shipments in transit through Canadian ports.

[5] Includes 56 countries in 2008 and 53 countries in 2009.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

U.S. IMPORTS FOR CONSUMPTION OF TALC, BY COUNTRY[1]

Country	Not crushed or powdered Quantity (metric tons)	Not crushed or powdered Value (thousands)	Crushed or powdered Quantity (metric tons)	Crushed or powdered Value (thousands)	Cut and sawed Quantity (metric tons)	Cut and sawed Value (thousands)	Total unmanufactured Quantity (metric tons)	Total unmanufactured Value (thousands)
2008:								
Brazil	363	$330	(2)	$35	1,210	$1,680	1,580	$2,040
Canada	7	8	59,400	17,900	11,100	9,320	70,500	27,200
China	97,600	19,700	(2)	190	1,330	1,620	98,900	21,500
France	--	--	(2)	343	--	--	--	343
Japan	--	--	18,300	1,510	58	140	18,400	1,650
Other[3]	596	306	2,190	1,010	772	2,320	3,560	3,630
Total	98,600	20,400	79,900	21,000	14,500	15,100	193,000	56,500
2009:								
Brazil	3	5	172	34	1,160	936	1,340	975
Canada	13	24	35,800	13,600	12,800	14,700	48,600	28,400
China	45,600	12,800	5,400	826	331	194	51,300	13,800
France	--	--	568	159	--	--	568	159
Japan	--	--	5,700	1,350	48	25	5,750	1,380
Other[3]	10	221	11,500	2,600	739	376	12,300	3,200
Total	45,600	13,100	59,100	18,600	15,100	16,300	120,000	47,900

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

[3] Includes 20 countries in 2008 and 18 countries in 2009.

Source: U.S. Census Bureau.

TABLE 6

TALC AND PYROPHYLLITE: WORLD PRODUCTION, BY COUNTRY AND PRODUCT[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Argentina:					
Pyrophyllite	8,470	9,340	9,340	9,230 [r]	9,000
Steatite[e]	-- [r]	-- [r]	-- [r]	-- [r]	-
Talc	12,603	13,773	14,956	12,988 [r]	13,000
Australia:[e, 4]					
Pyrophyllite	1,200	1,200	1,200	1,200	1,200
Talc	154,000	130,000	120,000	120,000	120,000
Austria, soapstone and talc, crude	166,569	159,447	153,409	154,577 [r]	150,000
Bhutan, talc	42,791	45,000 [e]	62,015 [r]	56,077 [r]	60,000
Brazil, talc and pyrophyllite	413,340	389,471	401,204	401,210 [r]	401,300 [r, 5]
Canada, pyrophyllite, soapstone, talc	70,000	72,000	79,000	70,000 [e]	44,000 [5]
Chile, talc	4,201	1,961	2,104	2,108 [r]	2,000
China, unspecified[e]	2,300,000	2,400,000	2,000,000	2,200,000	2,300,000
Colombia, pyrophyllite, soapstone, talc[e]	-- [r]	-- [r]	-- [r]	-- [r]	-
Egypt, pyrophyllite, soapstone, steatite, talc	38,780	40,000 [e]	41,000 [r]	44,000 [r]	45,000
Finland, talc[e]	542,000 [5]	550,000	550,000	550,000	500,000
France, talc, crude[e]	416,000	420,000	420,000	420,000	420,000
Guatemala, talc	1,631	526	1,291	1,030 [r]	6,355 [5]
Hungary, talc[e]	500	500	500	500	500
India:[e]					
Pyrophyllite	85,000	86,000	87,000	87,000	88,000
Steatite	545,000	560,000	555,000	560,000	550,000
Iran, talc[e, 6]	70,600 [5]	70,000	90,889 [r, 5]	90,000 [r]	90,000
Italy, steatite and talc	112,781	146,942	140,000 [e]	140,000 [e]	140,000
Japan:[e]					
Pyrophyllite	351,111 [5]	350,000	345,000	350,000 [r]	340,000
Talc	25,491 [5]	25,500	26,000	26,000 [r]	25,000
Korea, North, unspecified[e]	50,000	50,000	50,000	50,000	50,000
Korea, Republic of:					
Pyrophyllite	885,559	677,465	798,054	892,625 [r]	900,000
Talc	83,471	64,118	9,557	6,438 [r]	6,500
Macedonia, talc	1,955	1,025	1,775	977 [r]	1,000
Mexico, talc	64,827	9,834	9,800 [e]	32,410	32,400
Morocco[e]	2,000	2,000	2,000	2,000	2,000
Nepal, talc[7]	5,832	6,648	9,043	9,040 [r, e]	9,000
Norway, soapstone, steatite, talc[e]	29,000	28,000	28,000	28,000	28,000
Pakistan, pyrophyllite	20,564	24,529	28,000	26,000 [e]	25,000
Paraguay, pyrophyllite, soapstone, talc[e]	200	200	200	200	200
Peru:					
Pyrophyllite	14,300	14,500	13,925	14,733 [r]	14,750 [r, 5]
Talc	9,500	9,550	9,171	17,984 [r]	13,296 [5]
Portugal, talc	5,362	5,517	12,367	8,447 [r]	8,500 [r]
Romania, talc[e]	10,000	2,967 [5]	1,513 [5]	1,500	1,500
Russia, talc[e]	160,000	160,000	170,000	160,000	160,000
Slovakia, talc[e]	-- [r]	-- [r]	-- [r]	-- [r]	-
South Africa:					
Pyrophyllite	60,267	74,886	123,573	80,704	114,897 [5]
Talc	8,469	10,966	14,281	5,145	4,718 [5]

See footnotes at end of table.

TABLE 6—Continued
TALC AND PYROPHYLLITE: WORLD PRODUCTION, BY COUNTRY AND PRODUCT[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009[e]
Spain, steatite and talc[e]	100,000	100,000	100,000	100,000	100,000
Sweden, soapstone and talc	14,000	14,000	14,000	14,000 [e]	14,000
Thailand:					
Pyrophyllite	177,684	131,843	415,420	106,600 [r]	105,000
Talc	10,270	4,374	3,508	3,264 [r]	3,000
Turkey, talc and pyrophyllite	8,775	4,969	12,722	12,000 [e]	12,000
United Kingdom, pyrophyllite, soapstone, talc	6,000	6,000	6,000 [e]	6,000 [e]	6,000
United States:					
Pyrophyllite	W	W	W	W	W
Talc	856,000	895,000	769,000	706,000	511,000 [5]
Uruguay, pyrophyllite, soapstone, talc[e]	1,131 [5]	1,150	1,150	1,150	1,150
Zimbabwe, talc[e]	--	140	200	200	200
Grand total	7,950,000 [r]	7,770,000 [r]	7,700,000 [r]	7,580,000 [r]	7,430,000
Of which:					
Pyrophyllite	1,600,000	1,370,000	1,820,000	1,570,000 [r]	1,600,000
Steatite	545,000	560,000	555,000	560,000	550,000
Talc	2,490,000	2,430,000	2,300,000 [r]	2,230,000 [r]	1,990,000
Unspecified	3,310,000 [r]	3,410,000 [r]	3,030,000 [r]	3,220,000 [r]	3,290,000

[e] Estimated. [p] Preliminary. [r] Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through April 16, 2010.

[3] In addition to the countries listed, Nigeria may produce talc, but information is inadequate to estimate output.

[4] Data based on fiscal year ending June 30 of year stated.

[5] Reported figure.

[6] Data based on fiscal year beginning March 21 of year stated.

[7] Data based on fiscal year beginning mid-July of year stated.

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THORIUM

By E. Lee Bray

omestic survey data and tables were prepared by Shonta E. Osborne, statistical assistant, and the world production table s prepared by Lisa D. Miller, international data coordinator.

horium consumption worldwide is relatively small npared with that of most other mineral commodities. There s no domestic production of thorium reported in 2009. All rium alloys, compounds, and metal used by the domestic ustry were derived from company stocks, imports, or terial previously acquired from the U.S. Government kpile. Domestic imports for consumption of refined rium products increased by 224% in 2009, according to data lected by the U.S. Census Bureau (tables 1, 2). The value horium compounds used by the domestic industry in 2009 s $275,000, an increase of 128% from $121,000 in 2008. ly minor amounts, less than 10 metric tons (t) of thorium, typically used annually. However, large fluctuations in sumption are caused by intermittent use, especially for alytic applications that do not require annual replenishment. 2009, thorium compounds were imported from France (50%) l India (50%).

horium and its compounds were produced primarily from mineral monazite, which was recovered as a byproduct of cessing heavy-mineral sands for zircon and the titanium nerals ilmenite and rutile, or the tin mineral cassiterite. nazite was recovered primarily for its rare-earth content, and y a small fraction of the byproduct thorium produced was sumed. Monazite-producing countries in decreasing order of duction were India, Brazil, and Malaysia (table 3).

roblems associated with thorium's natural radioactivity resented a significant cost to those companies involved in mining, processing, manufacture, transport, and use. The sts to comply with environmental regulations and potential al liabilities and the high costs to purchase storage and waste posal space were the principal deterrents to its commercial .

imited demand for thorium, compared with demand for rare ths produced from thorium-containing minerals, continued create a worldwide oversupply of thorium compounds and idues. Most major rare-earth processors have switched feed terials to thorium-free intermediate compounds, such as e-earth chlorides, hydroxides, or nitrates. Excess thorium t designated for commercial use was either disposed of as ow-level radioactive waste or stored for potential use as a clear fuel or in other applications. Principal nonenergy uses ve shifted from refractory applications to chemical catalysts, hting, welding electrodes, and heat resistant ceramics, in scending order of use.

oduction

Domestic mine production data for thorium-bearing minerals re developed by the U.S. Geological Survey from a voluntary nvass of U.S. thorium operations. The one mine to which a nvass form was sent responded. Thorium was not produced in the United States in 2009, and the mine that had previously produced thorium-bearing monazite at Green Cove Springs, FL, (Iluka Resources Inc., a wholly owned subsidiary of Iluka Resources Ltd.) ceased production of zircon from tailings during the year. The monazite production capacity has been on standby for several years. Monazite was last produced in the United States in 1994.

Consumption

Statistics on domestic thorium consumption were developed by evaluating import and export data, and surveying various processors and manufacturers.

Domestic thorium producers and processors that were surveyed reported no consumption of thorium oxide equivalent in 2009 and were temporarily shut down owing to the lack of thorium demand. Additional information on domestic consumption was not available. Essentially all thorium alloys and compounds used by the domestic industry were derived from imports, company stocks, or materials previously sold from the National Defense Stockpile. Domestic companies processed or fabricated various forms of thorium for nonenergy uses, such as ceramics, chemical catalysts, lighting, and welding electrodes.

In August 2009, Lightbridge Corp. (formerly Thorium Power Ltd.) (McLean, VA) signed an agreement to provide consulting services to Areva Inc. (Paris, France) on the design of a light water reactor using thorium (Thorium Power Inc., 2009).

Prices

Thorium oxide prices in 2009, as quoted by Rhodia Inc., (Cranbury, NJ), (a subsidiary of Rhodia Electronics & Catalysis Sas., La Rochelle, Poitou-Charentes, France) were estimated to be the same as those of the previous year (table 1). At yearend, the estimated price for thorium oxide delivered, duty paid, was $300 per kilogram for 99.9% purity, the same as at yearend 2008. In 2007, the 99.99%-pure thorium oxide product was discontinued. Thorium nitrate prices from Rhodia were estimated to be unchanged at $27 per kilogram for mantle-grade material. Thorium nitrate was used in the manufacture of mantles for incandescent "camping" lanterns, including natural gas lamps and oil lamps. Thorium mantles provide an intense white light that is adjusted towards the yellow region by a small addition of cerium. Thoriated mantles were not produced domestically owing to the development of a suitable thorium-free substitute.

Foreign Trade

Exports of thorium compounds from the United States were 4,730 kilograms (kg) valued at $379,000, a decrease from

12,700 kg in 2008 (table 2). Principal destinations were, in order of quantity, China and Luxembourg.

Imports of thorium compounds in 2009 were from France and India and were 2,250 kg valued at $275,000, an increase from 692 kg valued at $121,000 in 2008 (table 2). Rhodia Electronics & Catalysis' rare-earth separation plant in La Rochelle remained the principal source of thorium compounds imported into the United States. Most of the thorium was supplied from older stocks that were produced when the plant was processing monazite. The La Rochelle plant processes intermediate rare-earth concentrates that have had the thorium removed. Imports of thorium ores and concentrates including monazite were 26,000 kg in 2009; no thorium ores or concentrates were imported in 2008.

World Review

Thorium demand worldwide remained depressed because of concerns over its naturally occurring radioactivity. Industrial consumers expressed concerns about the potential liabilities, the cost of environmental monitoring to comply with regulations, and the cost of disposal at approved waste burial sites. Interest in thorium increased worldwide as various countries have exhibited an interest in thorium-fueled nuclear power as an alternative to uranium. In 2009, geologic exploration for other resources associated with thorium continued in Canada, India, and the United States.

China.—Atomic Energy of Canada Ltd. signed a cooperation agreement with three Chinese organizations for the assessment of thorium use in the Candu pressurized heavy water reactor. Third Qinshan Nuclear Power Co., the Nuclear Power Institute of China, and China North Nuclear Fuel Corp. would jointly develop and demonstrate the use of thorium in the Candu reactor. The joint venture would lead to the construction of Candu reactors fueled by thorium in China, if proven feasible (World Nuclear News, 2009).

India.—The Indian Government continued to advance its three-stage plan to use its modest uranium and vast thorium resources. Its vast thorium resources are contained in numerous heavy-mineral sands deposits in the States of Andhra Pradesh, Kerala, Orissa, and Tamil Nadu. Thorium mineral resource wealth is considered the stable basis for the future of India's nuclear power program.

Russia.—In October, Lightbridge and Russian Limited Liability Research and Development Co. (SOSNY) (Moscow, Russia) signed an agreement for SOSNY to manage the research and development activities related to testing thorium in a Russian-designed nuclear reactor. Lightbridge had conducted initial analysis of safety and design aspects of its thorium fuel technology for the VVER–1000 reactor (Lightbridge Corp., 2009).

Outlook

Thorium has been found to some extent in every continent of the world, but is concentrated in a few geologic deposit types. There are three principal sources of thorium that are of commercial interest—monazite in heavy-mineral sand placer and vein deposits, thorite ores in vein deposits, and thorium recovered as a byproduct of uranium mining. Thorium use in the United States has decreased substantially during the past decade. Domestic consumption is expected to remain at recent low levels unless thorium's use as a nonproliferative nuclear fuel becomes widely commercialized or a low-cost technology is developed to dispose of thorium residues created as a byproduct during mineral processing, specifically monazite. In the long term, high disposal costs, increasingly stringent regulations, and public concerns related to thorium's natural radioactivity are expected to continue to discourage its use in nonenergy applications in the United States as well as worldwide.

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TABLE 1
SALIENT U.S. REFINED THORIUM STATISTICS[1]

(Kilograms and dollars per kilogram)

	2005	2006	2007	2008	2009
Exports, gross weight:					
Thorium ore, including monazite	--	--	-- [2]	-- [2]	18,000
Compounds	737	1,090	1,630	12,600	4,730
Imports, gross weight:					
Thorium ore, including monazite	--	10,000	--	--	26,000
Compounds	4,930	48,600	6,370	692	2,250
Prices, yearend:					
Nitrate, gross weight[3, 4]	27.00	27.00	27.00	27.00	27.00 [e]
Oxide, 99.9% purity[4]	82.50	175.00	200.00	300.00	300.00 [e]

[e] Estimated. -- Zero.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Data estimated by U.S. Geological Survey.

[3] Source: Rhodia Canada, Inc., free on board port of entry, duty paid, thorium oxide basis.

[4] Source: Rhodia Electronics and Catalysis, Inc.

TABLE 2
U.S. FOREIGN TRADE IN THORIUM AND THORIUM-BEARING MATERIALS[1]

	2008		2009		
	Quantity (kilograms)	Value	Quantity (kilograms)	Value	Principal destinations/sources and quantities, 2009
Exports:					
Thorium ore, monazite concentrate	-- [2]	-- [2]	18,000	$269,000	Canada 9,000; China 2,000; Other 7,000.
Compounds	12,700	$1,250,000	4,730	379,000	China 2,100; Luxembourg 1,300; France 404; Indonesia 250; Canada 230; Singapore 221; United Kingdom 144; Other 75.
Imports:					
Thorium ore, monazite concentrate	--	--	26,000	19,500	United Kingdom 26,000.
Compounds	692	121,000	2,250	275,000	France 1,130; India 1,120.

-- Zero.

Data are rounded to no more than three significant digits.

Data estimated by U.S. Geological Survey.

Source: U.S. Census Bureau.

TABLE 3
MONAZITE CONCENTRATE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country[3]	2005	2006	2007	2008	2009
Brazil	958 [4]	958 [4]	1,173 [4]	1,200	1,200
India	5,000	5,000	5,000	5,000	5,000
Malaysia	320 [4]	894 [4]	682 [4]	700	600
Total	6,280	6,850	6,860	6,900	6,800

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 9, 2010.

[3] In addition to the countries listed, China, Indonesia, Nigeria, North Korea, the Republic of Korea, and countries of the Commonwealth of Independent States may produce monazite, available information is inadequate for formulation of reliable estimates of ouput levels.

[4] Reported figure.

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TIN

By James F. Carlin, Jr.

Domestic survey data and tables were prepared by Linda M. White, statistical assistant, and the world production tables ere prepared by Lisa D. Miller, international data coordinator.

Tin has not been mined in the United States since 1993; nsequently, the country was reliant on imports and recycling r its tin needs. In 2009, 25 firms consumed 91% of the imary tin used domestically. The major uses were as follows: etal containers, 19%; solders, 16%; transportation, 16%; nstruction, 11%; and other, 38%. The estimated value of imary tin metal consumed domestically was $459 million. dustry stocks declined by 18% compared with those at arend 2008 (table 1). The Defense Logistics Agency (DLA) anaged the National Defense Stockpile (NDS).

Approximately 13,400 metric tons (t) of tin, most of it from d scrap, was recycled (table 5). About one-fourth of the tin nsumed in the United States was recycled metal.

World tin mine output decreased slightly compared with that 2008, and world primary tin smelter production increased y 7% compared with that of 2008 (tables 1, 9–10). Of the 20 untries in which tin was mined, the top 5 accounted for 92% f the total world tin production of 260,000 t. China was the ading producer (44% of world output), followed by Indonesia 1%), and Peru (14%). Industry analysts considered the world n market in 2009 to have a slight deficit of supply relative to onsumption. The composite tin price decreased by 26% from at of 2008. World tin reserves were estimated to be 5.2 million etric tons (Mt), about 16 times the estimated annual world rimary tin consumption of 350,000 t. Most tin reserves are in sia and South America.

egislation and Government Programs

In August 2008, the Defense National Stockpile Center DNSC) suspended sales of tin until further notice; therefore, he DLA sold no tin in 2009. The fiscal year annual materials lan for tin was set at 6,000 t. As of December 31, 2009, the tin nventory was 4,020 t, all of which was stored at the DNSC's epot in Hammond, IN (David Kotok, DLA Strategic Materials, ritten commun., January 11, 2011).

roduction

Mine.—Tin was not mined in the United States in 2009. Until 993, a few small tin mines had operated sporadically in the nited States; no mine production data have been reported to he U.S. Geological Survey (USGS) since that year.

Secondary.—Industry analysts considered the United States o be the world's leading producer of secondary or scrap tin. ost secondary tin was generated during manufacturing from arious scrapped alloys of tin and recycled in those same alloy ndustries. Secondary tin from recycled fabricated parts was sed in many kinds of products and was a particularly important ource of tin for the manufacture of brass and bronze and solder.

Consumption

In 2009, domestic consumption of primary tin increased by 8% compared with that in 2008 (tables 1, 2). Domestic consumption data for tin were developed by the USGS from a voluntary survey of tin consumers. Of the 105 firms to which a survey form was sent, 68 responded, including the major consumers. Data for the nonrespondents were estimated based on prior-year reporting.

The total number of metal cans shipped was 129 billion in 2009 compared with 132 billion in 2008. Steel (essentially tinplate and tin-free steel) dominated in the food, pet, and general line can markets, and aluminum held 100% of the beverage can market (Can Manufacturers Institute, 2009, p. 24).

Prices

The Platts Metals Week average composite price for tin metal decreased by 26% from that in 2008. Industry observers attributed the decline in price to selective decreases in some tin-consuming countries, partly owing to the effects of the economic slowdown. The London Metal Exchange Ltd. (LME) remained the principal trading site for tin.

Foreign Trade

U.S. imports of refined tin, which supplied most domestic tin requirements, decreased by 9% compared with those of 2008 (table 8). Imports of tin in all forms (metal, ore and concentrate, scrap, and waste) remained duty free, and were held in U.S. warehouses by trading firms until sold to customers. Foreign-owned trading firms tended to dominate the marketing of imports. U.S. imports of tin came mostly from Peru, Bolivia, Indonesia, China, and Brazil, in descending order. Refined tin exports were significantly less than imports (tables 6, 8).

World Review

The Association of European Producers of Steel for Packaging (Apeal) (Brussels, Belgium) reported that the recycling rate of packaging steels (mostly tinplate) reached a record 70% in Europe in 2008. About 2.5 Mt of food and drink cans and other steel containers were recycled, representing a slight increase from that in 2008. Apeal noted that these data make steel the leading recycled packaging material compared with glass (62%), cardboard (33%), and plastic (29%). Belgium was again the recycling leader in Europe, recycling 93% of its steel containers. Germany, Luxembourg, and the Netherlands followed closely behind, each recycling more than 87% of their steel containers (Canmaker, The, 2010).

Secondary or scrap production has long been an important component of the world's refined tin supply. Some sources estimated that 10% to 12% of world refined tin production came from secondary sources. Several companies announced the startup of new tin recycling plants in 2009.

The World Bureau of Metal Statistics (WBMS) issued data on world supply and demand in 2008, showing that of the six metals traded on the LME, tin was the only one with a supply deficit. However, world tin consumption fell more in 2008 than did consumption for the other metals. WBMS estimated that the world tin supply fell short of demand by 4,300 t in 2008. WBMS also estimated that tin consumption in China decreased by 5% in 2008, and Japan experienced a 6% decrease. The strongest market was Europe where consumption increased by 2% (ITRI Ltd., 2009).

CRU Tin Monitor (2009a) identified 12 companies that consistently produced more than 5,000 metric tons per year (t/yr) of tin. The firms and their 2008 refined tin production (in metric tons) were as follows:

1. Yunnan Tin Group Co., Ltd. (China), 58,400;
2. PT Timah Tbk (Indonesia), 49,000;
3. Minsur S.A. (Peru), 38,000;
4. Malaysia Smelting Corp. (Malaysia), 31,600;
5. Thailand Smelting and Refinery Co. Ltd. (Thailand), 21,700;
6. Yunnan Chengfeng Non-Ferrous Metals Co., Ltd. (China), 13,500;
7. Liuzhou China Tin Group, Ltd. (China), 12,000;
8. Metallo Chimique N.V. (Belgium), 9,200;
9. Em Vinto (Bolivia), 8,800;
10. PT Koba Tin (Indonesia), 7,100;
11. Gejiu Zi-Li Co., Ltd. (China), 7,000; and
12. Taboca/Paranapanema (Brazil), 6,100.

In a related study, CRU Tin Monitor (2009a) reported data showing the concentration of production ownership in tin in different countries compared with that in other major metals. With the top five refined tin producers accounting for 65% of world tin output, tin ranks number one among the seven major metals compared. The other metals and their degree of concentration in their respective metals were nickel (61%), aluminum (38%), gold (32%), zinc (30%), copper (28%), and lead (22%).

Argentina.—Silver Standard Resources Inc. (Vancouver, British Columbia, Canada) announced that its wholly owned Pirquitas project in Jujuy, began production of concentrate in December. The mine was primarily a silver mine, with significant tin and zinc byproducts; silver and tin concentrates were expected to account for about 95% of the mine's revenue. Silver Standard estimated that the cost to develop the Pirquitas facility was $230 million (TIN World, 2009a).

Australia.—Australia's Foreign Investment Review Board approved the proposed deal between Metals X Ltd. (East Perth, Western Australia) and Yunnan Tin Co. (YTC) (Kunming, Yunnan Province, China) for the sale of up to 60% of its interest in Metals X's Tasmanian assets for $55 million. Under the agreement, Yunnan Tin would pay Metals X an initial $45 million for a 50% stake in Metals X's wholly owned subsidiary, Bluestone Mines Tasmania, which operated the Tasmanian tin assets. Yunnan Tin would have the option of purchasing the remaining 10% stake for $9 million during the next 2 years. The two companies would form a joint venture to continue the development of the assets, which include the Renison Bell underground mine, the Mt. Bischoff open pit mine, the Renison tin concentrator plant, and the Rentails tailings retreatment project (Platts Metals Week, 2009c).

Bolivia.—Corporación Minera de Bolivia (Comibol) (La Paz), the parent company of Empresa Minera Huanuni (EMH) expected to spend $40 million to build a new mill at EMH's Oruro Mine, which would raise daily ore throughput to 3,000 metric tons per day (t/d) from 1,200 t/d. The mine produced 7,880 t of tin-in-concentrate in 2008 and was the country's leading tin mine (CRU Tin Monitor, 2009d).

Also, EMH announced plans to invest $2 million to build a tailings dam at the Huanuni Mine. Until December 2009, waste from the concentrator at the operation had been discharged straight into the local river, from which local community members scavenged tin not recovered at the mill (CRU Tin Monitor, 2009b).

The Government of Bolivia agreed to guarantee a $20 million investment to install a new Ausmelt furnace at the state-owned Vinto tin smelter. The new furnace would increase the smelter's treatment capacity to 38,000 t/yr of tin concentrate, allowing it to produce 17,000 t/yr of refined tin, an increase from 11,000 t/yr currently. The Government seized Vinto in February 2007 from the trading firm Glencore International AG (Baar, Switzerland) (Platts Metals Week, 2009a).

Brazil.—Data from Brazil's tin producers association, Sindicato Nacional da Industria e Extracao de Estanho (SNIEE) showed a 15% year-on-year decline in national tin mine production in January through September 2009. Total output of tin-in-concentrate was reported at 8,100 t, down from 9,500 t in the same period of 2008. The decline was owing to the sharp drop in production at Mineracao Taboca SA's (Manaus) Pitinga Mine as a result of a major reorganization of operations that began following Taboca's acquisition by Minsur S.A. (Lima, Peru) in late 2008. Production at Pitinga decreased by 55% to 2,200 t in the first 9 months of 2009. This was partly offset by a large increase in production by small-scale garimpeiro operations (CRU International Ltd., 2009c).

China.—Nanshan Tin Co. Ltd. commissioned a new tin smelter in Nankang Industrial Zone, Jiangxi Province, on April 9. The smelter had a design capacity of 10,000 t/yr of refined tin and cost $22 million. The startup took place at a time when Chinese tin smelters struggled to obtain sufficient raw materials owing to shortages of scrap. Nanshan Tin was reported to have a business relationship with a Jiangxi Province mining firm, which was likely to provide part of its concentrate feed (Metals Place, 2009).

Liuzhou China Tin Group Co. Ltd. (Liuzhou, Guangxi Province) was expected to be the fourth major world tin smelter to adopt Ausmelt tin smelting technology. Two of the world's leading producers, Minsur and YTC already operate large Ausmelt plants, and Bolivia's Vinto tin smelter planned to install a new unit in 2010–11. Liuzhou's new 20,000-t/yr capacity smelter was to be built alongside the existing facility at Liuzhou.

ity. Liuzhou China Tin produced 12,000 t of refined tin in 2008 CRU Tin Monitor, 2009b).

YTC reported promising initial results in the trial operation of hydrometallurgical method to recover copper, tin, and tungsten rom tailings. The project was conducted by Makuang Mining a subsidiary of YTC). The trial operation started in March and nvolved the processing of more than 10,000 t of ore with 0.6% opper, 0.2% tin, and 0.1% tungsten (CRU International Ltd., 009c).

Congo (Kinshasa).—Thailand Smelting and Refining Co. td. (Thaisarco) (Phuket, Thailand), the only tin smelting firm n Thailand, and a subsidiary of the multinational organization MC Group Ltd. (London, United Kingdom), announced on eptember 18 that it had suspended all purchases of tin ore from ongo (Kinshasa). The decision followed continued criticism y the Global Witness Organization, whose stated goal was o expose allegedly corrupt exploitation of natural resources. MC stated that Thaisarco would not enter into further ontracts with suppliers of tin ore unless it had the support f the United Nations and campaign groups for certification chemes. Thaisarco had been participating with the tin research rganization ITRI Ltd. (St. Albans, United Kingdom) to develop certification plan to verify the origin of shipments of tin ore. he first stage of the ITRI Tin Supply Chain Initiative was mplemented on July 1 and included, among other requirements, system for written confirmation of origin of the mineral from ach supplier. The deposits of cassiterite in Congo (Kinshasa), he chief source of tin, were found in a broad zone extending rom northern Shaba region through Sud-Kivu and Nord-Kivu rovinces to the Haut-Zaire region. These deposits were worked y artisanal miners using picks and shovels, and a single ontainer load of ore could be sourced from thousands of miners TIN World, 2009d).

Indonesia.—The Government set a tin production quota of 05,000 t in 2009, a 47% increase from tin output in 2008. Of he 105,000 t, 90,000 t would come from Bangka Island, which as many smelters, including those of PT Koba Tin (Jakarta) and T Timah Tin (Jakarta), and the remaining production would ome from the Riau Islands (Platts Metals Week, 2009b).

Tin smelter production in Indonesia experienced several etbacks during 2009. Independent tin smelters reported ontinuing problems in obtaining sufficient supplies of tin ore. he PT Bangka-Belitung Timah Sejahtera tin smelter operated t 30% to 40% below its capacity of 5,000 to 6,000 metric tons er month of refined tin for much of the year. Koba Tin [75% wned by Malaysia Smelting Corp. (Butterworth, Malaysia) and 5% by PT Timah Tbk (Bangka)] was forced to shut down two ravel pumps after they were flooded following heavy rains in ay (CRU International Ltd., 2009b).

Koba Tin announced plans to produce 9,000 t of tin in 2009. oba Tin produced 7,200 t of refined tin in 2008 including roduction from the treatment of stockpiled slags. The increase n production in 2009 would come from the opening of four ew gravel pumps and a planned resumption of small-scale ubcontractor mining. Koba Tin also operated one onshore redge (CRU International, Ltd., 2009a).

PT Latinusa Tbk (Jakarta) announced plans to nearly double ts tinplate production capacity to 250,000 t/yr by 2013–14. Production capacity in 2009 was 130,000 t/yr, with actual production expected to increase to 120,000 t in 2010 from 90,000 t in 2009. PT Latinusa was divesting 55% of its equity to a consortium headed by Nippon Steel Corp. (Tokyo, Japan) and a public offering of another 20% to raise funds for the expansion (CRU Tin Monitor, 2009c).

Japan.—Kosaka Smelting and Refining (Kosaka), Mitsui Mining and Smelting (Tokyo), and Nippon Mining & Metals Co. Ltd. (Tokyo) announced plans (separately) to recover tin, along with copper and precious metals, from the treatment of post-consumer electronics scrap and other materials. Nippon Mining completed the first phase of construction and partly started test operation of the Hitachi Metal Recycling Complex (HMC) (Ibaraki) project in September. The plant, located within an existing Nippon Mining copper refining and electronic components manufacturing complex in Hitachi City, has a capacity to produce 150 t/yr of antimony, 200 t/yr of bismuth, as well as 500 t/yr each of nickel and tin. HMC planned to recover the metals by leaching electronic and auto component scrap collected mainly in the Tokyo area (CRU Tin Monitor, 2009a).

Morocco.—Kasbah Resources Ltd. (South Perth, Western Australia, Australia) raised $2.5 million to fund further drilling at its Achmmach tin project in Morocco. The funds would be directed towards diamond drilling of 15,000 square meters in the Meknes Zone, which was part of a plan to complete a feasibility study on the project by June 2011 (CRU Tin Monitor, 2009d).

Poland.—Fenix Metals Ltd. (Tarnobrzeg) started up a new 3,500-t/yr vacuum distillation unit in Poland late in 2009 and planned to make a similar investment at its sister company, Falcon Metals Ltd. (Jebel Ali, United Arab Emirates). Fenix planned to produce 1,500 t of refined tin from scrap in 2009 and also was investing in additional processing technology that would allow it to treat more complex materials.

Russia.—The country's leading tin mining firm, JSC Sakhaolovo, LLC (Sakhaolova), reportedly near bankruptcy, ceased production and laid off almost all its employees. The firm's parent company (Tsvetmet Holding) abandoned the operation. All of Sakhaolovo's tin production comes from its Deputatsky deposit in the Ust-Yansky District. The only hope for Sakhaolovo's survival reportedly may be a Government bailout based on the mine's status as a national strategic resource (Marchmont News.com, 2009). The mine closure also affected the Novosibirsk Integrated Tin Works (NOK) (Novosibirsk), the country's sole refined tin producer. NOK stopped receiving tin concentrate from Sakhaolovo and was unable to offset the shortage with supplies from other sources (CRU Tin Monitor, 2009d).

Singapore.—Singapore Tin Industries Pty. Ltd. (STI) announced that it would put up its assets for tender, signaling the end of operations for the firm; STI had been closed since yearend 2008. YTC owned 51% of STI, and KJP International Corp. (Taipei, Taiwan) owned the remaining 49%. STI had the capacity to produce 36,000 t/yr of refined tin, and in 2007 had commissioned a 12,000-t/yr tin smelter on Bangka Island in Indonesia (CRU International Ltd., 2009a).

United Kingdom.—Western United Mines Ltd. (WUM) (Redruth), the owner of the South Crofty Tin Mine (Pool), announced a new focus in returning the mine to production during the next 2 years. Although long known as a tin mine in the area that has produced tin ore for more than 300 years, South Crofty was actually a polymetallic mine, containing copper, lithium, precious metals, and zinc. WUM thought that by recovering a range of base metals, the mine would take advantage of a range of fluctuating metal prices rather than being at the mercy of the rise and fall of tin prices. WUM planned to develop research projects with the Camborne School of Mines (Tremough) to implement this approach (TIN World, 2009c).

Zimbabwe.—The Zimbabwe Mining Development Corp. (ZMDC) (Harare) held discussions with a South African company to reopen the Kamativi Tin Mine. Kimativi was acquired by ZMDC in 1986 but closed in 1994 following a slump in global tin prices and the exhaustion of higher grade tin ores. During the mid-1980s, the opencast and underground operations together produced about 1,000 t/yr of tin-in-concentrate. At that time, ore grades were about 0.125% tin for the opencast operations and 0.15% to 0.35% tin for the underground operations (TIN World, 2009b).

Outlook

Domestic demand for primary tin worldwide was expected to increase moderately in the near term, at a rate of about 3% per year. That rate, however, could double in a few years if new applications—especially those in which tin is substituted for toxic materials, such as lead-free solders—continue to find acceptance in the marketplace.

World tin reserves appeared to be adequate to meet foreseeable demand. Secondary sources of tin were likely to remain an important component of supply, especially in the United States. The August 2008 cessation of tin sales from the NDS, unless revised, would end tin supply from this source. Domestic tin requirements were expected to continue to be met primarily through imports.

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TABLE 1
SALIENT TIN STATISTICS[1]

		2005	2006	2007	2008	2009
United States:						
Production, secondary, contained tin[e]	metic tons	11,700	11,600	12,200	11,700 [r]	11,100
Exports, refined tin	do.	4,330	5,490	6,410	9,800	3,170
Imports for consumption, refined tin	do.	37,500	43,300	34,600	36,300	33,000
Consumption, contained tin:						
Primary	do.	31,400	29,200	23,700	23,100 [r]	24,900
Secondary	do.	9,170	8,480	7,490	6,250	7,750
Stocks, yearend, U.S. industry, contained tin	do.	8,080	7,890	9,100	8,560	7,020
Prices, average, contained tin:						
New York, NY, market	cents per pound	360.94	419.49	679.50	864.53	641.62
Platts Metals Week composite	do.	483.05	565.12	899.48	1,128.97	837.08
London, United Kingdom	do.	334.00	398.00	659.05	836.76	615.15
Kuala Lumpur, Malaysia	do.	333.55	397.69	658.42	837.70	609.34
World, production, contained tin:	do.					
Mine	metric tons	296,000 [r]	291,000 [r]	301,000 [r]	257,000 [r]	260,000 [e]
Smelter:						
Primary	do.	324,000	320,000 [r]	327,000 [r]	305,000 [r]	325,000 [e]
Secondary	do.	20,100	19,100	18,600	18,000 [r]	17,300 [e]
Undifferentiated	do.	200	50	--	--	--

[e]Estimated. [r]Revised. do. Ditto. -- Zero.

[1]Data are rounded to no more than three significant digits, except prices.

TABLE 2
U.S. CONSUMPTION OF PRIMARY AND SECONDARY TIN[1]

(Metric tons of contained tin)

	2008	2009
Stocks, January 1[2]	8,760	8,940
Net receipts during year:		
Primary	22,700	26,200
Secondary	4,300	5,890
Scrap	2,410	2,170
Total receipts	29,400	34,300
Total available	38,200	43,200
Tin consumed in manufactured products:		
Primary	23,100 [r]	24,900
Secondary	6,250	7,750
Total	29,400 [r]	32,600
Intercompany transactions in scrap	402	285
Total processed	29,800 [r]	32,900
Stocks, December 31 (total available less total processed)	8,460	10,300

[r]Revised.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Includes tin in transit in the United States.

TABLE 3
U.S. CONSUMPTION OF TIN, BY FINISHED PRODUCT[1]

(Metric tons of contained tin)

Product	2008			2009		
	Primary	Secondary	Total	Primary	Secondary	Total
Alloys, miscellaneous[2]	1,980	235	2,210	1,960	W	1,960
Babbitt	568 r	36	604 r	288	31	319
Bar tin	767	--	767	245	--	245
Bronze and brass	1,130	1,330	2,460	987	1,260	2,240
Chemicals	5,440	W	5,440	9,290	W	9,290
Solder	5,110 r	W	5,110	5,110	W	5,110
Tinning	395	--	395	340	--	340
Tinplate[3]	6,840	--	6,840	6,130	--	6,130
Other[4]	720	4,650	5,370	532	6,470	7,000
Total	22,900	6,250	29,200	24,900	7,750	32,600

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes terne metal.

[3] Includes secondary pig tin and tin acquired in chemicals.

[4] Includes britannia metal, collapsible tubes and foil, jewelers' metal, pewter, tin powder, type metal, and white metal.

TABLE 4
U.S. INDUSTRY YEAREND TIN STOCKS[1]

(Metric tons)

	2008	2009
Plant raw materials:		
Pig tin:		
Virgin[2]	6,680 r	5,190
Secondary	504	527
In process[3]	865	856
Total	8,050 r	6,570
Additional pig tin:		
Jobbers-importers	314	266
Afloat to United States	190	190
Total	504	456
Grand total	8,560	7,020

[r]Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes tin in transit in the United States.

[3] Data represent scrap only, tin content.

TABLE 5

U.S. STOCKS, RECEIPTS, AND CONSUMPTION OF NEW AND OLD SCRAP AND TIN RECOVERED, BY TYPE OF SCRAP[1]

(Metric tons)

	Gross weight of scrap								
	Stocks,		Consumption			Stocks,	Tin recovered[e]		
Type of scrap	January 1	Receipts	New	Old	Total	December 31	New	Old	Total
2008:									
Copper-base scrap:									
Ingot makers	3,830 [r]	75,900 [r]	15,600 [r]	60,600 [r]	76,100 [r]	3,660 [r]	W	2,650	2,650 [r]
Brass mills[2]	--	W	W	--	W	--	1,390	--	1,390
Foundries and other plants	1,670	21,000	16,000	4,970	21,000	1,670 [r]	W	144	144
Total	XX	XX	XX	XX	XX	XX	1,390	2,790 [r]	4,180 [r]
Lead-base scrap	21,000 [r]	1,240,000 [r]	26,800	1,220,000	1,250,000 [r]	16,500	703	8,910	9,620 [r]
Tin-base scrap[3]	W	W	W	W	W	W	W	W	W
Grand total	XX	XX	XX	XX	XX	XX	2,100	11,700 [r]	13,800 [r]
2009:									
Copper-base scrap:									
Ingot makers	3,660	60,200	10,900	49,400	60,300	3,640	373	2,180	2,560
Brass mills[2]	--	W	W	--	W	--	1,170	W	1,170
Foundries and other plants	1,670	22,200	16,000	5,500	21,500	2,390	W	144	144
Total	XX	XX	XX	XX	XX	XX	1,550	2,330	3,870
Lead-base scrap	16,500	1,160,000	29,000	1,140,000	1,170,000	11,700	760	8,740	9,500
Tin-base scrap[3]	W	W	W	W	W	W	W	W	W
Grand total	XX	XX	XX	XX	XX	XX	2,310	11,100	13,400

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data. XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Consumption is assumed to be equal to receipts.

[3] Includes tinplate and other scrap recovered at detinning plants.

TABLE 6

U.S. EXPORTS OF TIN IN VARIOUS FORMS[1]

	2008		2009	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ingots and pigs	9,800	$62,000	3,170	$22,200
Tin scrap and other tin-bearing material except tinplate scrap (gross weight)[2]	14,500	65,600	11,600	46,200
Tinplate and terneplate (gross weight)[2]	247,000	192,000	224,000	175,000

[1] Data are rounded to no more than three significant digits.

[2] Includes rods, profiles, flakes, tubes, and pipes.

Source: U.S. Census Bureau.

TABLE 7

U.S. IMPORTS FOR CONSUMPTION OF TIN IN VARIOUS FORMS[1]

	2008		2009	
	Quantity (metric tons, gross weight)	Value (thousands)	Quantity (metric tons, gross weight)	Value (thousands)
Dross, skimmings, scrap residues, tin alloys, n.s.p.f.[2]	24,200	$33,300	81,300	$23,400
Miscellaneous[3]	XX	71,100	XX	36,200
Tin compounds	800	15,800	601	8,180
Tinplate and terneplate	292,000	271,000	295,000	366,000
Tinplate scrap	25,900	7,040	27,100	5,190

XX Not applicable.

[1] Data are rounded to no more than three significant digits.

[2] Not specifically provided for.

[3] Includes tinfoil, tin powder, flitters, metallics, and other manufactures, and n.s.p.f.

Source: U.S. Census Bureau.

TABLE 8

U.S. IMPORTS FOR CONSUMPTION OF UNWROUGHT TIN METAL, BY COUNTRY[1]

	2008		2009	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Belgium	8	$185	82	$647
Bolivia	4,980	92,400	6,300	82,300
Brazil	1,570	25,100	1,050	13,600
Canada	4	80	30	260
Chile	100	1,300	121	1,870
China	2,380	39,100	1,210	14,500
Germany	5	100	20	391
India	--	--	64	779
Indonesia	2,000	28,000	3,220	16,100
Malaysia	1,740	33,000	169	1,190
Mexico	29	273	--	--
Peru	20,900	363,000	20,300	266,000
Singapore	706	13,700	451	5,650
Switzerland	--	--	25	382
Taiwan	6	37	--	--
Thailand	1,670	36,300	15	158
United Kingdom	225	3,880	(2)	7
Other	--	--	1	5
Total	36,300	636,000	33,000	404,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9
TIN: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2005	2006	2007	2008	2009[e]
Australia	2,819	1,478	2,071	1,783	1,400
Bolivia	18,433 [r]	18,444 [r]	15,972	17,320 [r]	19,273 [3]
Brazil	11,739	9,528	11,835 [r]	13,000 [r]	13,000
Burma[4]	708	923	830	741	672 [3]
Burundi	4	46	2	21	21
China[e]	126,000	126,000	146,000	110,000	115,000
Congo (Kinshasa)[e]	4,400	3,800	8,900	11,800	9,400
Indonesia	78,404	80,933	66,137	53,228 [r]	55,000
Laos	450	450	700 [r]	700 [r]	700
Malaysia	2,857	2,398	2,263	2,605 [r]	2,380
Mexico	17	25	25	15	15
Niger[e]	14	13	11	10	10
Nigeria[e, 5]	1,300	1,400	180 [r]	185 [r]	180
Peru	42,145	38,470	39,019	39,037	37,503 [3]
Portugal	243	25	41 [r]	29 [r]	30
Russia[e]	3,000	3,000	2,500	1,500	1,200
Rwanda	140 [r]	390 [r]	740 [r]	980 [r]	850
Thailand	158 [e]	190	120	120 [e]	120
Uganda	2	2	2	2	2
Vietnam[e]	3,500	3,500	3,500	3,500	3,500
Total	296,000 [r]	291,000 [r]	301,000 [r]	257,000 [r]	260,000

[e] Estimated. [r] Revised.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 10, 2010.

[3] Reported figure.

[4] Includes content of tin-tungsten concentrate.

[5] Concentrate gross weight reported, estimated 62% tin content.

TABLE 10
TIN: WORLD SMELTER PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2005	2006	2007	2008	2009[e]
Australia:					
Primary	594	572	118	170 [r]	7,637 [3]
Secondary[e]	300	400	400	400	400
Total[e]	894	972	518	570 [r]	8,037
Belgium, secondary[e]	7,000	6,000	5,000	5,000	5,000
Bolivia, primary	13,941 [r]	14,089 [r]	12,251	12,666 [r]	14,715 [3]
Brazil:					
Primary	8,986	8,780	9,384 [r]	10,308 [r]	10,550 [p, 3]
Secondary[e]	250	250	250	250	250
Total	9,236	9,030	9,634 [r]	10,558 [r]	10,800
Bulgaria, secondary[e]	10	10	10	10	10
Burma, primary[e]	30	30	30	30	30
China, primary[e]	122,000	132,000	149,000	129,000	135,000
Czech Republic, secondary[e]	100	100	100	100	100
Denmark, secondary[e]	100	100	100	75	75
Greece, secondary[e]	100	100	100	75	75
Indonesia, primary	65,300	65,357	64,127	53,417 [r]	54,000
Japan, primary	754	854	879	986 [r]	980
Malaysia, primary	36,924	22,850	25,263	31,630 [r]	36,407 [3]
Mexico, primary	17	25	25	15	15
Nigeria, primary[e]	25	--	--	--	--
Norway, secondary[e]	50	50	50	50	50
Peru, primary	36,733	40,495	36,004	38,865	38,900 [r]
Russia:[e]					
Primary	5,000	4,980	3,800	2,000	1,700
Secondary	500	500	400	300	300
Total	5,500	5,480	4,200	2,300	2,000
Rwanda	200	50	--	--	-- [3]
Spain, secondary[e]	10	10	10	10	10
Thailand, primary	31,600	27,540	23,104 [r]	21,860 [r]	21,000
United States, secondary	11,700	11,600	12,200	11,700 [r]	11,100 [3]
Vietnam, primary	1,766	2,665 [r]	3,369 [r]	3,566 [r]	3,600
Grand total	344,000	339,000	346,000 [r]	322,000 [r]	342,000
Of which:					
Primary	324,000	320,000 [r]	327,000 [r]	305,000 [r]	325,000
Secondary	20,100	19,100	18,600	18,000 [r]	17,300
Undifferentiated	200	50	--	--	--

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Whenever possible, total output has been separated into primary (from ores and concentrates) and secondary (tin metal recovered from old scrap). This table reflects metal production at the first measurable stage of metal output. Table includes data available through July 10, 2010.

[3] Reported figure.

TITANIUM

By Joseph Gambogi

Domestic survey data and tables were prepared by Elsie D. Isaac, statistical assistant, and the world production table was repared by Lisa D. Miller, international data coordinator.

World production of titanium dioxide (TiO_2) contained in .anium mineral concentrates decreased by 10% compared with at of 2008. The United States continued to be heavily reliant imports of titanium mineral concentrates from Australia, anada, and South Africa.

Global TiO_2 pigment production capacity was estimated to e 5.6 million metric tons per year (Mt/yr). According to U.S. eological Survey (USGS) survey data, domestic production of iO_2 pigment decreased by 9% compared with that of 2008.

Consumption of titanium used in steel and other alloys ecreased by 22% from that in 2008 because of the global onomic recession that began in 2008. In 2009, the recession d delays in aircraft programs resulted in decreased domestic roduction of titanium ingot and mill products.

egislation and Government Programs

The Defense Advanced Research Projects Agency (DARPA) ontinued to fund work on low-cost extraction of titanium etal from oxide ores. DARPA efforts were aimed at producing igh-quality titanium at a cost of less than $8.81 per kilogram. fiscal year (FY) 2009, DARPA hoped to produce up to .1 metric tons per day and verify that the cost of production as less than the target cost. In FY 2010, DARPA planned to emonstrate consolidation of titanium powder without using onventional melting techniques (Defense Advanced Research rojects Agency, 2009, p. 183).

In 2009, the U.S. Department of Defense (DOD) initiated two rograms to improve the supply of titanium metal. International itanium Powder (ITP) (a subsidiary of Cristal Global) entered nto a Title III agreement with DOD to increase domestic apacity to produce low-cost metallic titanium powder. Title III f the Defense Production Act (50 U.S.C. App. 2061 et seq.) is a rogram specifically designed to establish, expand, maintain, or nodernize industrial capabilities required for national defense. nstead of sponge produced by magnesium reduction via the roll process, the plant was designed to produce titanium metal owder by sodium reduction via the Armstrong process. At earend, ITP neared completion of new titanium production apacity in Ottawa, IL, and was expected to begin production n 2010. Production capacity was expected to be 2,000 metric ons per year (t/yr) by yearend 2011 (International Titanium owder, 2009). A second Title III effort was aimed at reducing ost and shortening delivery lead times for structural titanium nd titanium armor. The initial goal of the second program was o direct roll titanium in widths and thicknesses that can be used or armor tiles on military ground vehicles (U.S. Department of efense, 2009, p. 89–90).

In response to Congressional requests, a DOD-led Strategic nd Critical Materials Working Group was formed to review he present state of the National Defense Stockpile. In April, a report was sent to Congress recommending the transformation of the National Defense Stockpile into a Strategic Materials Security Program (SMSP). Within the report, several initiatives were recommended for consideration. On an ongoing basis, the SMSP would conduct risk assessments, compare demand to supply by analyzing supply sources and risks of supply chain interruption, and identify mitigation strategies. The proposed SMSP would leverage the buying power of Government by aggregating materials requirements and negotiating long-term strategic sourcing arrangements. The working group also developed a plan for a comprehensive Strategic Materials Security Management System (SMSMS) that would identify, on an ongoing basis, those strategic and critical materials required for national security. The SMSMS would be a joint effort by the Office of the Secretary of Defense, the military services, the Defense Contract Management Agency, and the Defense Logistics Agency, with representation and analysis provided by other Government agencies such as the U.S. Department of Commerce and the USGS (Defense Logistics Agency, 2009, p. 1–3).

Production

Titanium industry data for this report are collected by the USGS from annual and quarterly surveys of domestic titanium operations. In 2009, the USGS annual survey canvassed titanium mineral and pigment production operations. The two producers of titanium mineral concentrates responded, but data were withheld to avoid disclosing company proprietary information. Of the seven domestic TiO_2 pigment operations, five responded, representing 85% of TiO_2 pigment production. Two TiO_2 pigment operations were estimated on the basis of prior-year production levels. Production of titanium ingot and mill products was aggregated from a quarterly survey of producers.

Mineral Concentrates.—Titanium mineral concentrates of economic importance include ilmenite, leucoxene, rutile, synthetic rutile, and titaniferous slag. Mining of titanium minerals is usually performed using surface methods. Dredging and dry mining techniques are used for the recovery of heavy minerals. Gravity spirals are used to separate the heavy-mineral suite, while magnetic and high-tension separation circuits are used to separate the heavy-mineral constituents. Ilmenite is often processed to produce a synthetic rutile or titaniferous slag. Although numerous technologies are used to produce synthetic rutile, nearly all are based on either selective leaching or thermal reduction of iron and other impurities in ilmenite. Titaniferous slag with a TiO_2 content of 75% to 95% is produced commercially using pyrometallurgical processes.

U.S. mineral concentrate producers were DuPont Titanium Technologies [a subsidiary of E.I. du Pont de Nemours and

Co. (DuPont)] and Iluka Resources, Inc. (a subsidiary of Iluka Resources Ltd.). DuPont's mining operations near Starke, FL, produced a mixed product containing ilmenite, leucoxene, and rutile that was used as a feedstock in DuPont's TiO_2 pigment plants. In 2009, Iluka produced titanium mineral concentrates from its heavy-mineral operations at Stony Creek, VA.

Iluka began mining at its Brink deposit in Virginia to extend the life of its Virginia mining operations to 2015. The Brink deposit is about 48 kilometers south of the Stony Creek, VA, mineral separation plant. At Green Cove Springs, FL, Iluka ceased reprocessing of stockpiled tailings (Iluka Resources Ltd., 2010, p. 2, 44).

Metal.—Commercial production of titanium metal involves the chlorination of titanium-containing mineral concentrates to produce titanium tetrachloride ($TiCl_4$), which is reduced with magnesium (Kroll process) or sodium (Hunter process) to form a commercially pure form of titanium metal. As the metal is formed, it has a porous appearance and is referred to as sponge. Titanium ingot and slab are produced by melting titanium sponge or scrap or a combination of both, usually with various other alloying elements such as aluminum and vanadium. Electron beam (EB), plasma arc melt (PAM), scull, and vacuum-arc remelting (VAR) are the commercial methods used to produce ingot and slab. Titanium mill products are produced from the drawing, forging, and rolling of titanium into products of various sizes and shapes. These mill products include billet, pipe and tube, plate, rod and bar, sheet, strip, and wire. Titanium castings are produced by investment casting and rammed graphite mold casting. Ferrotitanium is usually produced by induction melting of titanium scrap with iron or steel, but may be produced through the aluminothermic reduction of ilmenite. The two standard grades of ferrotitanium that are normally produced contain 40% and 70% titanium. Domestic ferrotitanium capacity was estimated to be 17,300 t/yr.

In 2009, U.S. producers of titanium sponge were Allegheny Technologies Inc. (ATI), Honeywell Electronic Materials Inc., and Titanium Metals Corp. (Timet). ATI's Albany, OR, plant and Timet's Henderson, NV, plant produced titanium sponge using the Kroll process. Honeywell Electronic Materials' plant in Salt Lake City, UT, produced titanium sponge using the Hunter process and supported the company's production of electronic-grade titanium. Data on domestic production of titanium sponge were withheld to avoid disclosing company proprietary data (table 2).

In July, owing to poor market conditions and in anticipation of new production capacity, ATI temporarily idled its 9,980-t/yr sponge plant in Albany, OR (Allegheny Technologies Inc., 2009, p. 44). In December, ATI commissioned a new 10,900-t/yr sponge facility in Rowley, UT (Allegheny Technologies Inc., 2010, p. 24).

At yearend, RTI International Metals, Inc. neared completion of production capacity expansions at its Canton (ferrotitanium and specialty alloys) and Niles (titanium ingot), OH, operations. No details were available in regard to the size of the expansions. RTI ceased construction of a 9,070-t/yr sponge plant near Hamilton, MS, in favor of long-term titanium sponge supply agreements with foreign suppliers (RTI International Metals, Inc., 2010, p. 3).

Timet completed an 8,500-t/yr expansion of EB ingot production capacity in Morgantown, PA. The new capacity increased the company's ingot production capacity at Morgantown to 40,700 t/yr (Titanium Metals Corp., 2010).

In 2009, U.S. production of titanium ingot was 35,600 metric tons (t), a 39% decrease compared with the near-record production in 2008. Production of mill products decreased by 20% compared with that of 2008 (table 3). U.S. producers of ferrotitanium were RTI (Canton, OH) and Global Titanium Inc. (Detroit, MI). Data on production of ferrotitanium were not available.

TiO_2 Pigment.—TiO_2 pigment is produced from titanium mineral concentrates by either the chloride process or the sulfate process. In the chloride process, rutile is converted to $TiCl_4$ by chlorination in the presence of petroleum coke. $TiCl_4$ is oxidized with air or oxygen at about 1,000° C, and the resulting TiO_2 is calcined to remove residual chlorine and any hydrochloric acid that may have formed in the reaction. Aluminum chloride is added to the $TiCl_4$ to assure that virtually all the titanium is oxidized into the rutile crystal structure. In the sulfate process, ilmenite or titanium slag is reacted with sulfuric acid. Titanium hydroxide is then precipitated by hydrolysis, filtered, and calcined. Although either process may be used to produce pigment, the decision of which process to use is based on numerous factors, including raw material availability, freight, and waste disposal costs. In finishing operations, the crude form of the pigment is milled to produce a controlled distribution of particle size and surface treated or coated to improve its functional behavior in different media. Some typical surface treatments include alumina, organic compounds, and silica.

TiO_2 pigment produced by either process is categorized by crystal form as either anatase or rutile. Rutile pigment is less reactive with the binders in paint when exposed to sunlight than is the anatase pigment and is preferred for use in outdoor paints. Anatase pigment has a bluer tone than rutile, is somewhat softer, and is used mainly in indoor paints and in paper manufacturing. Depending on the manner in which it is produced and subsequently finished, TiO_2 pigment can exhibit a wide range of functional properties, including dispersion, durability, opacity, and tinting.

U.S. production of TiO_2 pigment was 1.23 million metric tons (Mt) in 2009, a 9% decrease compared with that in 2008 (table 5). U.S. producers of TiO_2 pigment by the chloride process were Cristal Global, DuPont, Louisiana Pigment Co. L.P. (a joint venture of NL Industries, Inc. and Huntsman Corp.), and Tronox Inc. (table 4). TOR Minerals International, Inc. produced a buff TiO_2 pigment from finely ground synthetic rutile.

In January, Tronox filed for reorganization under chapter 11 of the U.S. Bankruptcy Code. At yearend, Tronox announced that it negotiated a framework for a reorganization plan with a new debt facility, new equity financing, the establishment of environmental remediation trusts, and a litigation trust under a comprehensive settlement of legacy environmental liabilities with the U.S. Government. In 2009, Tronox was among the world's leading producers of TiO_2 pigment (PRNewswire-FirstCall, 2009).

Consumption

Mineral Concentrates.—On a gross weight basis, 95% of the domestic consumption of titanium mineral concentrates was used to produce TiO_2 pigment. The remaining 5% was used to produce miscellaneous other products, including fluxes, metal, and welding rod coatings. Based on TiO_2 content, domestic consumption of titanium mineral concentrates was 1.36 Mt, a 5% decrease compared with that of 2008 (table 6). Consumption data for titanium concentrates were estimated by the USGS owing to insufficient response by industry to the voluntary survey for consumption data.

Metal.—Titanium metal alloys are used for their high strength-to-weight ratio and corrosion resistance. Because of delays in aircraft programs and uncertain market conditions, consumption of titanium ingot decreased 37% compared with that of 2008 (table 3).

Domestic shipments of titanium metal mill products decreased by 21%. The aerospace industry (79%) was the leading end use for mill products. Other uses included those in the consumer goods, marine, medical, oil and gas, pulp and paper, and specialty chemical industries.

A significant quantity of titanium in the form of ferrotitanium, scrap, and sponge is consumed in the steel and nonferrous alloy industries. In the steel industry, titanium is used for deoxidation, grain-size control, and controlling and stabilizing carbon and nitrogen content. Titanium-intensive steels include interstitial-free, stainless, and high-strength low-alloy steels. Reported domestic consumption of titanium products in steel and other alloys was 9,290 t, a 22% decrease compared with that of 2008 (table 7).

TiO_2 Pigment.—Led by a decrease in the demand for coatings and plastics used in construction and automobiles, domestic consumption of TiO_2 pigment decreased by 5% compared with that of 2008 (table 5). The leading uses of TiO_2 pigment, based on TiO_2 pigment shipments in the United States, were paint and coatings (58.6%), plastics and rubber (25.5%), and paper (9.4%). Other uses (6.5%) included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules (table 8).

Stocks

Insufficient data were available to determine yearend consumer inventories of titanium mineral concentrates and TiO_2 pigment producer stocks. Industry reports indicated that in 2009 the global decrease in the production of mineral concentrates and TiO_2 pigment resulted in a reduction in stocks.

Owing to long-term supply agreements, domestic stocks of sponge increased by 8% compared with those in 2008. Domestic stocks of ingot decreased by 25% because producers reduced production in anticipation of decreased consumption (table 3).

Prices

Titanium mineral concentrate prices are listed in table 9. Although lower during much of the year, yearend prices for bulk ilmenite and rutile concentrates were higher compared with prices in 2008. Published prices for titanium slag were not available. Based on U.S. Customs Service data, the yearend unit value of slag imports ranged from $401 to $439 per metric ton in 2008 compared with $393 to $407 per ton in 2008. The unit value of slag hit a low in the first quarter with a range of $331 to $411 per ton.

The U.S. Department of Labor, Bureau of Labor Statistics, yearend producer price index (PPI) for TiO_2 pigment decreased by 3% compared with that of 2008. The monthly PPI started the year at a low of 154, hit a peak of 172 in November, and then fell to 164 by yearend (U.S. Department of Labor, Bureau of Labor Statistics, 2010).

Delays in large aircraft programs, an uncertain global economy, and excess inventory caused prices of titanium mill products to fall significantly. The monthly PPI for titanium mill products reached a high of 281 in February and declined to a low of 197 by yearend. Sponge and ingot prices were less affected by reduced demand because of long-term contracts and significant curtailments in production.

Foreign Trade

Mineral Concentrates.—Imports of titanium mineral concentrates include ilmenite, rutile, synthetic rutile, and titaniferous slag. The United States was heavily reliant on imports of titanium mineral concentrates because domestic consumption of titanium minerals greatly exceeded domestic production capacity. In 2009, the TiO_2 content of imports was estimated to be 763,000 t, primarily in the form of titaniferous slag (46%) and natural rutile (28%). South Africa, Australia, and Canada, in descending order of quantity, were the leading import sources. The combined value for all forms of titanium concentrate imports in 2009 was $330 million (table 11). Because of reduced steel production, imports of titaniferous iron ore from Canada, classified as ilmenite by the U.S. Census Bureau, decreased significantly. Exports of titanium concentrates were minor relative to imports (tables 10, 11).

Metal.—Imports of titanium metal are primarily in the form of unwrought titanium and scrap. Kazakhstan (60%) and Japan (35%) were the leading sources of imported titanium sponge, while France (25%), the United Kingdom (24%), Germany (19%), and Japan (11%) were the leading sources of imported scrap. The leading import sources of titanium ingot were Germany (69%) and Russia (29%). China (71%) was the major source of titanium powder. Imports of powder and other unwrought forms of titanium decreased by 82% and 69%, respectively, compared with those of 2008.

Imports of titanium wrought products and castings were primarily in the form of plate, sheet, strip, and foil (37%); bar, rod, profiles, and wire (25%); and billets (24%). Russia (76%) and China (7%) were the leading sources of wrought products and castings imports. Imports of wrought products and castings decreased from a record high set in 2008.

Owing to decreased consumption of titanium for steel and other alloys, imports of ferrotitanium and ferrosilicon titanium were 2,540 t, a 10% decrease compared with those of 2008. The leading import sources were Canada (32%), the United Kingdom (31%), and Russia (25%). Exports of ferrotitanium and ferrosilicon titanium were 2,020 t, a 25% increase compared with those of 2008.

TiO_2 Pigment.—The United States continued to be a net exporter of TiO_2 pigment. In 2009, exports exceeded imports by a ratio of 3.7 to 1. Exports of TiO_2 pigment were 649,000 t, an 11% decrease compared with those of 2008. About 95% of TiO_2 pigment exports was in the form of finished pigment with 80% or more TiO_2 content.

During 2009, 175,000 t of TiO_2 pigment was imported, a 4% decrease compared with that in 2008. The leading import sources of TiO_2 pigment were Canada (39%) and China (12%). Pigment imports were primarily in the form of pigment with more than 80% TiO_2 (table 13).

World Review

Australia.—Iluka began production of heavy-mineral concentrate at its Jacinth-Ambrosia Mine in the Eucla Basin, South Australia. During its projected mine life of more than 10 years, Jacinth-Ambrosia was expected to produce approximately 1.5 Mt of ilmenite, 350,000 t of rutile, and 2.8 Mt of zircon (Iluka Resources Inc., 2009b).

In Western Australia, Iluka idled its Eneabba Mine because of declining ore grades and the opening of the Jacinth-Ambosia Mine. In 2009, Iluka was in the process of upgrading the Narngulu mineral separation plant to process heavy-mineral concentrate from the Jacinth-Ambrosia concentration plant (Iluka Resources Inc., 2009a).

The Australian Government approved Astron Ltd.'s environmental plan to develop its Donald heavy-mineral deposit in the Murray Basin, Victoria. Astron planned to produce heavy-mineral concentrate from Donald and then process the concentrate through a mineral sand separation plant in China (Astron Ltd., 2009, p. 6). According to Astron, the deposit contained an indicated and inferred resource of ilmenite (8.5 Mt), leucoxene (5.4 Mt), rutile (1.2 Mt), and zircon (5.2 Mt) (Astron Ltd., undated).

Australian Zircon NL suspended mining activities at its Mindarie operation in South Australia, and the company went into administration to obtain relief from its creditors. During 2009, the company continued a feasibility study of the WIM150 deposit and produced ilmenite, rutile, and zircon from previously mined ore through yearend (Mineral Sands Report, 2009a). Although no data were available for 2009, in 2008, the Mindari operation produced about 8,600 t of ilmenite and 3,000 t of rutile in 2008 (Geoscience Australia, 2009, p. 48).

In May, Unimin Australia Ltd. acquired Consolidated Rutile Ltd. (CRL) from Iluka (Mineral Sands Report, 2009b). In 2009, the CRL Mine on North Stradbroke Island, Queensland, was reported to contain reserves of 3.2 Mt of heavy minerals (Iluka Resources Ltd., 2010, p. 75).

Canada.—Sustainable Development Technology Canada awarded Titanium Corp.'s "Creating value from waste" project $4.9 million in funding. The award was expected to promote technologies that recover bitumen and heavy minerals, including ilmenite and rutile, from oil sands tailings. Consortium members of the project included Sojitz Corp., Syncrude Canada Ltd., Titanium Corp., and the Government of Alberta (Titanium Corp., 2009).

Citing the slump in construction activity and weakness in the automotive sector, Rio Tinto Fer et Titane shut down its titaniferous magnetite mine near Lac Allard, Quebec, and its smelting operations in Sorel, Quebec, for 8 weeks in the summer (Rio Tinto plc, 2009, p. 1).

Chile.—White Mountain Titanium Corp. (WMT) was proceeding with the exploration and development of its Cerro Blanco rutile deposit. In December, WMT completed a pilot-plant test to produce a natural rutile concentrate meeting the specifications of titanium pigment and sponge metal producers. WMT planned to complete a study for commercial feasibility by the first quarter 2011 (White Mountain Titanium Corp., 2010, p. 16).

China.—Despite a drop in domestic consumption, China's titanium metal and pigment production capacity continued to rise. The top five sponge producers increased capacity to 63,000 t/yr in 2009 from 44,000 t/yr in 2008. However, owing to market conditions, several less-efficient sponge plants were idled in 2009. Total sponge production capacity was estimated to be more than 80,000 t/yr (Dewhurst, 2010, p. 15–17). TiO_2 production was reported to have reached a record 1.04 Mt, a 259,000-t increase from that in 2008. Owing to rising domestic consumption, TiO_2 production was expected to increase to 1.2 Mt in 2010 and may reach 1.9 Mt by 2015 (Titanium Dioxide Report, 2010). Although the development of domestic mine production was ongoing, increased consumption of titanium concentrates was met through increased imports of titanium mineral concentrates. In 2009, Chinese imports of titanium mineral concentrates increased to 1.48 Mt from 1.07 Mt in 2008 (United Nations Statistics Division, undated).

Hainan Taixin Minerals Co. Ltd. acquired mining rights to a heavy-mineral deposit near Wanning City, Hainan Province. The deposit was reported to have a proven reserve of ilmenite (2.24 Mt) and zircon (0.5 Mt). While granting the mining rights, the Provincial government stipulated that the company would be required to produce value-added products beyond ilmenite and zircon concentrates (Mineral Sands Report, 2009c).

Germany.—Huntsman Corp. closed its 40,000-t/yr TiO_2 pigment plant at Grimsby. According to the company, the Grimsby plant was its oldest and least-efficient manufacturing facility. Huntsman produced TiO_2 pigment in seven countries with a combined production capacity of approximately 560,000 t/yr (Huntsman Corp., 2009).

India.—Trimex Group was preparing to begin production of up to 200,000 t/yr of ilmenite and 6,000 t/yr of rutile in the Srikurmam district, Andhra Pradesh. Proven reserves reportedly were estimated to be 5.5 Mt of ilmenite (Industrial Minerals, 2008).

Kerala Minerals & Metals Ltd. (KMML) continued construction on a 500-t/yr titanium sponge plant. $TiCl_4$ was to be supplied to the plant from KMML's Chavara TiO_2 pigment plant. The plant was scheduled to be in production by June 2010 (Kerala Minerals & Metals Ltd., undated).

Japan.—Although curtailing production in 2009, Toho Titanium Co., Ltd. was proceeding with plans to increase its total sponge production capacity to 28,000 t/yr through the addition of a new 12,000-t/yr plant at Wakamatsu, Fukuoka Prefecture (Metal-Pages, 2009a).

In the Hyogo Prefecture, Osaka Titanium technologies Co. Ltd. delayed plans to increase capacity at its Amagasaki sponge ant to 41,000 t/yr. In 2008, the production capacity was raised v 33% to 32,000 t/yr (Bloomberg.com, 2009).

Kazakhstan.—Ust-Kamenogorsk Titanium-Magnesium omplex, the sole producer of titanium sponge in Kazakhstan, ared completion of new ingot production capacity. A ,000-t/yr ingot plant was expected to be commissioned in 10 and reach full production capacity in 2011 (Metal-Pages td., 2010).

Kenya.—In August, Jinchuan Group Ltd. entered into an nderstanding with Tiomin Resources Inc. wherein Jinchuan ould acquire 70% of Tiomin Kenya Ltd.'s (TKL) Kwale ineral sands project; however, in October, Jinchuan terminated e agreement. At yearend, Tiomin abandoned plans to develop e deposit and wrote off all the costs associated with the Kwale roject. In early 2010, Tiomin changed its name to Vaaldiam lining Inc. (Vaaldiam Mining Inc., 2010, p. 12).

Madagascar.—QIT Madagascar Minerals SA (QMM) was mping up production at its 700,000-t/yr mineral sands project ear Mutamba. QMM was a joint venture between Rio Tinto plc nd the Government of Madagascar. Rio Tinto began exporting 0% grade ilmenite to its slag operation at Sorel, Quebec (Rio into plc, 2010, p. 2).

Mozambique.—BHP Billiton Ltd. completed a prefeasibility udy of the Corridor Sands heavy-minerals project and oncluded that further development of the project was not arranted (BHP Billiton Ltd., 2009, p. 33). The Corridor Sands roject was based on 10 deposits near Chibuto in southern lozambique. Previously, total resources of ore were estimated be 14 billion metric tons, with the largest deposit containing bout 300 Mt of ilmenite.

Kenmare Resources plc was addressing startup problems hat prevented the Moma operation from achieving its design apacity of 800,000 t/yr of ilmenite, 14,000 t/yr of rutile, and 0,000 t/yr of zircon. In 2009, the Moma operation produced bout 474,000 t of ilmenite concentrate. The company also nade plans to increase its design capacity by about 50% by 012 (Kenmare Resources plc, 2010, p. 6).

Norway.—Nordic Mining ASA was developing an eclogite leposit at Engebøfjellet in Sogn and Fjordane County. In 009, Nordic Mining's work was related to mineral resource rospecting and developing methods for ore dressing and eneficiation for the production of rutile and garnet. Nordic Mining also submitted a proposal with an environmental impact tatement for the development of the deposit to the Naustdal and Askvoll municipalities. In 2010, the company planned to focus on optimizing rutile recovery and prepare for pilot-plant roduction (Nordic Mining ASA, 2010).

Russia.—ARZM Uranium Holding Co. was developing the Lukoyanovskoye heavy-minerals sands deposit near Nizhny Novgorod. ARZM planned to commission a mine and processing plant with the capacity to process up to 1.5 Mt/yr of heavy-mineral concentrates by 2014. According to the Russian classification system, ore reserves in categories "C1" and "C2" were estimated to be 30 Mt containing about 1 Mt of titanium and more than 350,000 t of zirconium oxide (ARZM Uranium Holding Co., 2009).

VSMPO-AVISMA Corp. decided to postpone an expansion of its titanium sponge production capacity to 42,000 t/yr until 2015. VSMPO was proceeding with plans to increase its capacity to produce downstream products such as sheet and forgings (Metal-Pages, 2009b).

Senegal.—A feasibility study of Mineral Deposits Ltd.'s Grande Cote deposit was underway in 2009. The study was expected to be completed in 2010 and was to include updated capital costs, circuit model test work, financial modeling, geological block modeling, hydrological modeling, and mine path design (Mineral Deposits Ltd., 2010b). The company planned to produce up to 75,000 t/yr of zircon and 600 t/yr of ilmenite for a mine life of more than 25 years (Mineral Deposits Ltd., 2010a).

Sierra Leone.—Construction of Titanium Resources Group Ltd.'s (TRG) third mining dredge was underway, and the dredge was expected to be commissioned in 2011. At yearend, repairs to TRG's second dredge that capsized in July 2008 were pending the resolution of its insurance claim. In 2010, TRG expected its rutile production to increase by 30% from 63,900 t produced in 2009 (Titanium Resources Group Ltd., 2010, p. 1, 13).

South Africa.—In December, Rio Tinto Iron & Titanium concluded a Broad Based Black Economic Empowerment transaction at Richards Bay Minerals (RBM) in South Africa. Under the transaction, 24% of the equity of RBM was sold to a consortium of historically disadvantaged groups, with an additional 2% transferred to a trust for the benefit of RBM employees. The remaining 74% was split equally between BHP Billiton and Rio Tinto (Rio Tinto plc, 2010, p. 22).

Exxaro Resources Ltd. decided not to proceed with the development of the Fairbreeze mineral sands mine in KwaZulu-Natal. Subsequently, Exxaro planned to close the KZN Sands operations during the next 5 years unless new feedstock alternatives were located. Exxarro postponed restarting a slag furnace at its Namakwa Sands operation, which was shut down to be relined in March 2009. In addition, production at the mine and separation plants was temporarily halted in August to adjust for market conditions (Exxaro Resources Ltd., 2010, p. 48–49).

Ukraine.—Rutile-Ilmenite Co. (RICO) was preparing to mine and process heavy-mineral sands at its deposit in Tarasovka. In 2011, RICO planned to produce 51,000 t of heavy-mineral concentrates including ilmenite (6,000 t), leucoxene (20,000 t), rutile (15,000 t), and zircon (10,000 t). In 2012, production was expected to reach its maximum capacity of 196,000 t/yr (Industrial Minerals, 2009).

Vietnam.—In an effort to assist the domestic mining industry, the Government of Vietnam temporarily lifted a ban on exports of heavy-mineral concentrates. Producers were permitted to export from mid-2009 through the end of 2010. The ban had been imposed to encourage the production of value-added products. In 2008, the export tariff for zircon ore was raised to 20% from 15% (Mineral Sands Report, 2009d).

Outlook

For the foreseeable future, the market for titanium minerals was expected to be driven by the production of TiO_2 pigment. Unless new mines are developed, the U.S. reliance on imports of titanium mineral concentrates is likely to increase as existing mines are depleted within the next 10 years.

During the next decade, global demand growth for TiO_2 was expected to track with the total global gross domestic product and the production of paint, paper, and plastics. Higher-than-average growth was expected in Asia. China, in particular, was expected to lead world growth in production and consumption. TiO_2 production capacity in China was scheduled to double by the end of the decade. During the next several years, prices for TiO_2 pigment were expected to rise because of increasing costs for caustic soda, chlorine, coke, and energy.

Aerospace, defense, and industrial uses were expected to strongly influence consumption of titanium metal for the foreseeable future. Commercial aircraft will remain a major consumer of titanium metal. The growth of the global airplane fleet was projected to average 3.3% per year from 2009 to 2029 (Boeing Co., The, 2010, p. 4). Within the next 3 years, global titanium metal production was expected to increase in line with the construction of new aircraft and increased industrial output. Government and private industry programs were working to commercialize lower cost methods of producing titanium metal.

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TABLE 1

SALIENT TITANIUM STATISTICS[1]

		2005	2006	2007	2008	2009
United States:						
Mineral concentrate:						
Imports for consumption	metric tons	1,190,000	1,230,000	1,460,000	1,380,000 [r]	943,000
Consumption[e, 2]	do.	1,720,000	1,870,000	1,950,000	1,780,000 [r]	1,700,000
Sponge metal:						
Imports for consumption	do.	15,800	24,400	25,900	23,900	16,600
Consumption	do.	26,100	28,400	33,700	W	W
Price, yearend[3]	dollars per pound	3.46–12.22	5.87–12.84	6.33–7.06	6.16–8.02	4.50–7.07
Titanium dioxide pigment:						
Production	metric tons	1,310,000	1,370,000	1,440,000	1,350,000	1,230,000
Imports for consumption	do.	341,000	288,000	221,000	183,000	175,000
Consumption, apparent	do.	1,130,000 [4]	1,080,000 [5]	979,000 [5]	800,000 [5]	757,000 [5]
Producer price index, yearend[6]	(1982=100)	172	165	162	170	164
World, production:						
Ilmenite concentrate[7]	metric tons	6,050,000	6,850,000 [r]	7,120,000 [r]	6,870,000 [r]	6,180,000
Rutile concentrate, natural[8]	do.	377,000 [r]	515,000 [r]	604,000 [r]	628,000 [r]	577,000
Titaniferous slag[e]	do.	1,880,000	2,160,000	2,230,000 [r]	2,230,000	2,000,000

[e] Estimated. [r] Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Excludes consumption used to produce synthetic rutile.

[3] Landed duty-paid unit based on U.S. imports for consumption.

[4] Production plus imports minus exports plus stock decrease or minus stock increase.

[5] Production plus imports minus exports. Excludes stock changes.

[6] Source: U.S. Department of Labor, Bureau of Labor Statistics.

[7] Includes U.S. production of ilmenite, leucoxene, and rutile rounded to one significant digit to avoid disclosing company proprietary data.

[8] U.S. production of rutile included with ilmenite to avoid disclosing company proprietary data.

TABLE 2

U.S. TITANIUM METAL PRODUCTION CAPACITY IN 2009[1,2]

(Metric tons per year)

Company	Plant location	Yearend capacity[e] Sponge	Ingot[3]
Alcoa Howmet	Whitehall, MI	--	3,200
Allegheny Technologies Inc.	Albany, OR	(4)	10,900
Do.	Monroe, NC	--	23,200
Do.	Richland, WA	--	10,000
Do.	Rowley, UT	10,900	--
Alloy Works LLC	Greensboro, NC	--	1,800
Honeywell Electronic Materials Inc.	Salt Lake City, UT	500	--
Perryman Co.	Houston, PA	--	1,800
RTI International Metals, Inc.	Niles, OH	--	13,600
Titanium Metals Corp.	Henderson, NV	12,600	12,300
Do.	Morgantown, PA	--	40,700
Do.	Vallejo, CA	--	800
Total		24,000	118,000

[e] Estimated. Do. Ditto. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Estimated operating capacity based on 7-day-per-week full production.

[3] Includes electron-beam, plasma, and vacuum-arc-remelting capacity.

[4] In July 2009, sponge capacity of 9,980 metric tons per year was temporarily idled.

TABLE 3

COMPONENTS OF U.S. TITANIUM METAL SUPPLY AND DEMAND[1]

(Metric tons)

Component	2008	2009
Production:		
Ingot	58,600	35,600
Mill products	39,700	31,900
Exports:		
Waste and scrap	8,180	4,200
Sponge	2,370	820
Other unwrought	3,440	3,790
Wrought products and castings	19,000	12,500
Total	33,000	21,300
Imports:		
Waste and scrap	10,400	4,770
Sponge	23,900	16,600
Other unwrought	1,540	573
Wrought products and castings	8,350	6,930
Total	44,200	28,900
Stocks, industry, yearend:		
Sponge	14,200	15,300
Scrap	W	9,880
Ingot	3,590	2,680
Consumption, reported:		
Sponge	W	W
Scrap	23,200	25,700
Ingot	47,700	30,100
Shipments:		
Ingot	17,200	10,600
Mill products (net shipments):		
Forging and extrusion billet	12,300	9,520
Plate, sheet, strip	15,600	11,400
Rod, bar, fastener stock, wire	(2)	(2)
Other[3]	6,940	6,700
Total	34,800	27,700
Castings (shipments)	W	W
Receipts, scrap:		
Home	(4)	10,600
Purchased	(4)	17,700
Total	31,900	28,300

W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Included with "Other."

[3] Data for pipe, tube, and other have been combined to avoid disclosing company proprietary data.

[4] Withheld to avoid disclosing company proprietary data; included in "Total."

TABLE 4

U.S. PRODUCERS OF TITANIUM DIOXIDE PIGMENT IN 2009[1,2,3]

(Metric tons per year)

Company	Plant location	Yearend capacity[4]
Cristal Global	Ashtabula, OH	220,000
Du Pont Titanium Technologies	De Lisle, MS	340,000
Do.	Edgemoor, DE	154,000
Do.	New Johnsonville, TN	380,000
Louisiana Pigment Co. L.P.	Lake Charles, LA	146,000
Tronox Inc.	Hamilton, MS	225,000
Do.	Savannah, GA	(5)
Total		1,470,000

Do. Ditto.

[1] Estimated operating capacity based on 7-day-per-week full production.

[2] Table does not include TOR Minerals International, Inc.'s Corpus Christi, TX, production capacity of about 26,400 metric tons per year (t/yr) of buff TiO_2 pigment that is produced by refining and fine grinding of synthetic rutile.

[3] Data are rounded to no more than three significant digits; may not add to total shown.

[4] All plants use the chloride process to manufacture TiO_2 pigment.

[5] Tronox Inc. idled its 110,000-t/yr plant in the fourth quarter of 2009.

TABLE 5

COMPONENTS OF U.S. TITANIUM DIOXIDE PIGMENT SUPPLY AND DEMAND[1]

		2008		2009	
		Gross weight	TiO_2 content	Gross weight	TiO_2 content
Production[2]	metric tons	1,350,000	1,270,000 r, e	1,230,000	1,150,000 e
Shipments:[3]					
Quantity	do.	1,390,000	1,300,000 e	1,280,000	1,200,000 e
Value	thousands	$3,070,000	XX	$2,830,000	XX
Exports	metric tons	733,000	688,000 e	649,000	609,000 e
Imports for consumption	do.	183,000	172,000 e	175,000	165,000 e
Consumption, apparent[e, 4]	do.	800,000	751,000	757,000	711,000

[e] Estimated. [r] Revised. do. Ditto. XX Not applicable.

[1] Data are rounded to no more than three significant digits.

[2] Excludes production of buff pigment.

[3] Includes interplant transfers.

[4] Production plus imports minus exports. Excludes stock changes.

Sources: U.S. Census Bureau and U.S. Geological Survey.

TABLE 6
ESTIMATED U.S. CONSUMPTION OF TITANIUM CONCENTRATE[1, 2]

(Metric tons)

	2008		2009	
	Gross weight	TiO_2 content	Gross weight	TiO_2 content
Pigment	1,670,000	NA	1,620,000	NA
Miscellaneous[3]	115,000 r	NA	78,400	NA
Total	1,780,000 r	1,440,000 r	1,700,000	1,360,000

rRevised. NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes a mixed product containing altered ilmenite, leucoxene, and rutile.

[3] Includes alloys, carbide, ceramics, chemicals, glass fibers, titanium metal, and welding-rod coatings and fluxes.

TABLE 7
U.S. CONSUMPTION OF TITANIUM IN STEEL AND OTHER ALLOYS[1, 2]

(Metric tons)

	2008	2009
Steel:		
Carbon steel	5,930	4,660
Stainless and heat-resisting steel	3,270	2,600
Other alloy steel[3]	636	517
Total steel	9,840	7,780
Cast irons	16	12
Superalloys	1,060	462
Alloys, other than above	1,030	965
Miscellaneous and unspecified	40	72
Grand total	12,000	9,290

[1] Includes ferrotitanium, scrap, sponge, and other titanium additives.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Includes high-strength low-alloy and tool steel.

TABLE 8
U.S. DISTRIBUTION OF TITANIUM PIGMENT SHIPMENTS, TITANIUM DIOXIDE CONTENT, BY INDUSTRY[1]

(Percent)

Industry	2008	2009
Paint, varnish, lacquer	59.2	58.6
Paper	10.1	9.4
Plastics and rubber	24.5	25.5
Other[2]	6.2	6.5
Total	100.0	100.0

[1] Excludes exports.

[2] Includes agricultural, building materials, ceramics, coated fabrics and textiles, cosmetics, food, paper, and printing ink. Also includes shipments to distributors.

TABLE 9
YEAREND PRICES OF TITANIUM PRODUCTS

		2008	2009
Concentrate:			
Ilmenite, free on board (f.o.b.) Australian ports[1]	dollars per metric ton	84–137	60–85
Rutile, bagged, f.o.b. Australian ports[1]	do.	675–725	700–800
Rutile, bulk, f.o.b. Australian ports[1]	do.	500–550	525–540
Titaniferous slag, import, 80% to 95% TiO_2[2]	do.	393–407	401–439
Metal:			
Sponge import[2]	dollars per pound	6.16–8.02	4.50–7.07
Scrap, turnings, unproccessed[3]	do.	0.45–0.55	0.90–1.00
Ferrotitanium, 70% Ti[3]	do.	2.95–3.05	2.12–2.20
Mill products[4]	producer price index	233	197
Titanium dioxide pigment[4]	do.	170	164

do. Ditto.

[1] Source: Industrial Minerals.

[2] Landed duty-paid unit value based on U.S. imports for consumption.

[3] Source: Platts Metals Week.

[4] 1982=100. Source: U.S. Department of Labor, Bureau of Labor Statistics.

TABLE 10
U.S. EXPORTS OF TITANIUM BY CLASS[1]

		2008		2009	
Class	HTS[2]	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Metal:					
Scrap	8108.30.0000	8,180	$52,000	4,200	$14,000
Unwrought:					
Sponge	8108.20.0010	2,370	41,100	820	8,560
Ingot	8108.20.0030	725	19,500	776	19,800
Other	8108.20.0090	2,710	51,300	3,020	41,300
Wrought:					
Billet	8108.90.6010	3,200	135,000	2,010	75,200
Bloom, sheet bar, slab	8108.90.6020	1,980	60,900	913	26,900
Bar, rod, profile, wire	8108.90.6031	3,300	210,000	2,300	130,000
Other	8108.90.8000	10,500	714,000	7,240	476,000
Total		33,000	1,280,000	21,300	792,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	1,620	9,090	2,020	7,360
Ores and concentrates	2614.00.0000	14,900	8,590	14,800	8,230
Pigment:					
80% or more titanium dioxide pigment	3206.11.0000	668,000	1,310,000	617,000	1,230,000
Other titanium dioxide pigment	3206.19.0000	60,200	152,000	28,000	67,000
Unfinished titanium dioxide[3]	2823.00.0000	5,040	10,400	3,500	7,720
Total		733,000	1,470,000	649,000	1,310,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

[3] Unmixed and not surface treated.

Source: U.S. Census Bureau.

TABLE 11

U.S. IMPORTS FOR CONSUMPTION OF TITANIUM CONCENTRATE, BY COUNTRY[1]

Concentrate and country	HTS[2]	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)
Ilmenite:	2614.00.6020				
Australia		218,000	$23,200	105,000	$10,200
Mozambique		98,600	8,050	120,000	8,840
South Africa		87,500	33,700	--	--
Other		29,000	3,690	25,000	2,770
Total		433,000	68,600	250,000	21,800
Titaniferous slag:	2620.99.5000				
Canada		106,000	45,700	109,000	44,600
South Africa		355,000	141,000	305,000	123,000
Other[3]		--	--	91	32
Total		461,000	187,000	414,000	168,000
Rutile, natural:	2614.00.6040				
Australia		136,000	77,200	122,000	70,700
Canada		39,700	17,300	--	--
South Africa		176,000	84,800	75,700	37,100
Other[3]		12,900	7,840	26,100	15,000
Total		365,000	187,000	224,000	123,000
Rutile, synthetic:	2614.00.3000				
Australia		111,000	40,300	48,000	14,000
Malaysia		3,090 [r]	2,080 [r]	4,790	2,920
Other[3]		7,650 [r]	3,000 [r]	2,810	848
Total		122,000	45,400	55,600	17,700
Titaniferous iron ore, Canada[4]	2614.00.6020	140,000	44,600	10,000	532

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

[3] All or part of these data have been referred to the U.S. Census Bureau for verification.

[4] Includes materials consumed for purposes other than production of titanium commodities, principally heavy aggregate and steel-furnace flux. Titaniferous iron ore from Canada is classified as ilmenite under the HTS.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 12

U.S. IMPORTS FOR CONSUMPTION OF TITANIUM METAL, BY CLASS AND COUNTRY[1]

		2008		2009	
Class and country	HTS[2]	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
aste and scrap:	8108.30.0000				
Canada		728	$2,950	341	$563
China		199	1,550	--	--
France		1,560	14,000	1,220	5,500
Germany		1,310	10,500	903	3,940
Israel		363	2,020	6	6
Japan		1,960	12,600	505	1,700
Korea, Republic of		252	1,850	100	683
Mexico		233	711	90	136
Russia		158	2,030	--	--
Taiwan		441	2,450	133	516
United Kingdom		2,660	14,200	1,140	3,190
Other		581 [r]	4,010 [r]	335	1,400
Total		10,400	68,900	4,770	17,600
nwrought:					
Sponge:	8108.20.0010				
China		1,510	18,500	81	1,130
Japan		7,860	121,000	5,870	81,600
Kazakhstan[e]		12,000	110,000	9,930	88,800
Ukraine		1,540	18,300	--	--
Other		966	10,000	725	6,470
Total		23,900	278,000	16,600	178,000
got:	8108.20.0030				
Germany		771	25,200	364	10,300
Russia		466	9,370	155	2,830
Other		107	2,220	12	223
Total		1,340	36,800	531	13,300
owder:	8108.20.0015				
Canada		17	1,200	1	427
China		94	2,420	17	385
Japan		17	3,520	4	1,070
Other		6 [r]	576 [r]	2	509
Total		134	7,710	24	2,390
ther:	8108.20.0091				
Canada		9	969	1	275
China		17	187	(4)	6
Germany		7	61	10	202
Netherlands		19	156	2	14
United Kingdom		6	55	4	572
Other		2 [r]	138	1	151
Total		59	1,570	18	1,220

ee footnotes at end of table.

TABLE 12—Continued
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM METAL, BY CLASS AND COUNTRY[1]

Class and country	HTS[2]	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Va (thous
Wrought products and castings:[3]	8108.90.3030, 8108.90.3060, 8108.90.6010, 8108.90.6020, 8108.90.6031, 8108.90.6045, 8108.90.6060, 8108.90.6075				
China		1,070	$45,700	470	[illegible]
Germany		356	21,900	121	[illegible]
Japan		325	19,300	229	[illegible]
Russia		5,590	178,000	5,260	[illegible]
United Kingdom		377	32,200	309	[illegible]
Other		625	51,000	536	[illegible]
Total		8,350	349,000	6,930	[illegible]
Ferrotitanium and ferrosilicon titanium	7202.91.0000	2,830	14,900	2,540	[illegible]

[e]Estimated. [r]Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

[3] Includes bar, billet, bloom, castings, foil, pipe, plate, profile, rod, sheet, sheet bar, slab, strip, tube, wire, and other.

Source: U.S. Census Bureau.

TABLE 13

U.S. IMPORTS FOR CONSUMPTION OF TITANIUM PIGMENT, BY COUNTRY[1]

Country	HTS[2]	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)
80% or more titanium dioxide pigment:	3206.11.0000				
Belgium		2,820	$5,120	3,120	$6,100
Canada		74,300	150,000	59,600	130,000
China		6,590	12,800	9,910	15,600
Finland		9,260	20,000	8,290	19,100
France		1,820	3,360	3,150	5,980
Germany		4,730	11,100	6,970	14,900
Italy		6,210	10,800	4,870	9,120
Japan		2,940	11,500	3,300	12,800
Netherlands		3,200	5,950	3,620	6,880
South Africa		--	--	10,300	21,300
Spain		5,070	8,840	1,580	3,100
Ukraine		4,450	7,620	6,150	9,560
Other		13,800 [r]	23,700 [r]	9,380	16,500
Total		135,000	271,000	130,000	271,000
Other titanium dioxide:	3206.19.0000				
Canada		5,930	20,300	8,160	20,700
China		1,070	4,510	766	2,880
Germany		615	2,430	2,500	7,800
Japan		719	6,460	509	5,450
Korea, Republic of		630	1,000	307	588
Other		1,590 [r]	8,400 [r]	712	6,430
Total		10,500	43,100	13,000	43,900
Unfinished titanium dioxide:[3]	2823.00.0000				
China		9,620	17,800	9,880	14,200
Czech Republic		2,290	4,240	1,920	3,480
Finland		1,790	4,410	1,800	4,450
France		2,800	10,500	4,350	14,500
Germany		4,510	10,400	3,570	7,750
Japan		5,710	15,600	5,240	16,900
Korea, Republic of		2,880	4,770	2,980	3,890
United Kingdom		5,290	6,680	670	1,140
Other		2,210 [r]	4,740 [r]	1,510	3,800
Total		37,100	79,300	31,900	70,100
Grand total		183,000	393,000	175,000	385,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

[3] Unmixed and not surface treated.

Source: U.S. Census Bureau.

TABLE 14

TITANIUM: WORLD PRODUCTION OF MINERAL CONCENTRATES, BY COUNTRY[1, 2]

(Metric tons)

Concentrate type and country	2005	2006	2007	2008	2009
Ilmenite and leucoxene:[3, 4]					
Australia	2,080,000	2,508,000	2,503,000	2,199,000	1,700,000
Brazil[5]	81,818 [r]	94,909 [r]	100,364 [r]	175,076 [r]	71,122
China[e]	900,000	1,000,000	1,100,000	1,000,000 [r]	900,000
India[e]	686,000	690,000	700,000	610,000 [r]	700,000
Kazakhstan[e]	10,000	25,000	25,000	25,000	25,000
Madagascar	--	--	--	--	78,000 [e]
Malaysia	38,196	45,649	60,250 [r]	36,779 [r]	15,983
Mozambique	--	--	140,515	328,875	471,524
Norway[e]	810,000 [r]	850,000	882,000 [r]	915,000 [r]	671,000
Sierra Leone	--	13,819	15,750	17,528	15,161
Sri Lanka[e]	50,000	50,000	50,000	50,000	50,000
Ukraine	375,000 [e]	470,000	500,000	520,000 [r]	500,000 [e]
United States[e, 6]	500,000	500,000	400,000	300,000	300,000
Vietnam[e, 7]	523,000	605,000	643,000 [r]	693,000 [r]	687,000
Total[8]	6,050,000	6,850,000 [r]	7,120,000 [r]	6,870,000 [r]	6,180,000
Rutile:[4]					
Australia	177,000	232,000	312,000	325,000	280,000
Brazil[5]	2,069 [r]	2,100 [r]	3,000 [r]	2,431 [r]	2,881
India[e]	20,100	21,000	21,000	21,000	21,000
Madagascar	--	--	--	--	2,000 [e]
Mozambique	--	--	8,782	6,552	1,697
Sierra Leone	--	73,802	82,527	78,908	63,864
South Africa[e]	115,000	123,000	114,000	127,000	134,000
Sri Lanka[e]	3,000	3,000	3,000	7,500	12,000
Ukraine[e]	60,000	60,000	60,000	60,000	60,000
United States	(9)	(9)	(9)	(9)	(9)
Total	377,000 [r]	515,000 [r]	604,000 [r]	628,000 [r]	577,000
Titaniferous slag:[e, 10]					
Canada	860,000	930,000	960,000	1,000,000	765,000
South Africa	1,020,000	1,230,000	1,270,000 [r]	1,230,000	1,230,000
Total	1,880,000	2,160,000	2,230,000 [r]	2,230,000	2,000,000

[e]Estimated. [r]Revised. -- Zero.

[1] Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 14, 2010.

[3] Ilmenite is also produced in Canada and South Africa, but this output is not included here because most of it is duplicative of output reported under "Titaniferous slag," and the rest is used for purposes other than production of titanium commodities, principally steel furnace flux and heavy aggregate.

[4] Small amounts of titanium minerals were reportedly produced in various countries; information, however, is inadequate to make reliable estimates of output levels.

[5] Excludes production of unbeneficiated anatase ore.

[6] Includes rutile to avoid disclosing company proprietary data. Rounded to one significant digit.

[7] Estimate based on import statistics from trading partners (primarily China and Japan).

[8] Includes U.S. production, rounded to one significant digit, of ilmenite, leucoxene, and rutile to avoid disclosing company proprietary data.

[9] Included with ilmenite to avoid disclosing company proprietary data.

[10] Slag is also produced in Kazakhstan, Norway, and Russia, but this output is not included under "Titaniferous slag" to avoid duplicative reporting.

TUNGSTEN

By Kim B. Shedd

omestic survey data and tables were prepared by Lisa Mersdorf, statistical assistant, and the world production table was pared by Lisa D. Miller, international data coordinator.

2009, one U.S. tungsten operation shipped ore entrates. Most of the U.S. supply of tungsten raw materials prised imports, tungsten-bearing scrap, releases from stry stocks, and sales of excess materials from the National ense Stockpile (NDS). China continued to be the world's ling producer of tungsten concentrates and the leading lier of tungsten imports to the United States. In 2009, U.S. arent consumption decreased as a result of the economic ntum that began in late 2008. Salient U.S. tungsten statistics world tungsten concentrate production for 2009 and the ious 4 years are listed in table 1.

ost data in this report have been rounded to three significant ts. Totals and percentages were calculated from unrounded bers. Unless otherwise specified, all statistics in this report are etric tons of contained tungsten. Tungsten prices and many sten statistics from other sources are quoted in units of tungsten ide (WO_3). The short ton unit, which is used in the United es, is 1% of a short ton (20 pounds), and WO_3 is 79.3% tungsten veight. A short ton unit of WO_3, therefore, equals 20 pounds of $)_3$ and contains 7.19 kilograms (kg) (15.86 pounds) of tungsten. metric ton unit, which is used in most other countries, is 1% of etric ton (10 kg). A metric ton unit of WO_3, therefore, equals 10 f WO_3 and contains 7.93 kg (17.48 pounds) of tungsten.

ungsten is a whitish-gray metal with many unique properties a wide variety of commercial, industrial, and military lications. The leading use is as tungsten carbide in cemented ides, which are wear-resistant materials used by the struction, metalworking, mining, and oil and gas drilling ustries. Tungsten alloy and pure tungsten metal contacts, trodes, and wires are used in electrical, electronic, heating, ting, and welding applications. Tungsten is also used to ke heavy-metal alloys for armaments, heat sinks, radiation lding, and weights and counterweights; superalloys for ine engine parts; tool steels; and wear-resistant alloy parts l coatings. Tungsten alloys and composites are used as a stitute for lead in bullets, shot, and other products. Tungsten micals are used to make catalysts, corrosion-resistant tings, dyes and pigments, fire-resistant compounds, ricants, phosphors, and semiconductors.

gislation and Government Programs

he Defense National Stockpile Center (DNSC), U.S. partment of Defense (DOD), had two sales formats for NDS gsten materials—negotiated sales and a strategic supply ance (SSA). Under the SSA format, prequalified purchasers ld submit bids for tungsten ores and concentrates via the SC Web site at any time, 24 hours per day and 7 days week. During fiscal year 2009 (October 1, 2008, through tember 30, 2009), 262 metric tons (t) of contained tungsten s sold. At the end of the fiscal year, 11 t of tungsten metal powder had been sold but not shipped from the stockpile. During the calendar year, 773 t of tungsten was sold. The quantities of uncommitted tungsten materials remaining in the stockpile at the end of the calendar year are listed in tables 1 and 2 (U.S. Department of Defense, 2010, p. 8, 60).

The Annual Materials Plan (AMP) for fiscal year 2009, which represented the maximum quantities of tungsten materials that could be sold, is listed in table 2. The AMP for fiscal year 2010 (October 1, 2009, through September 30, 2010) was to remain unchanged for the tungsten materials remaining in the stockpile (U.S. Department of Defense, 2010, p. 6–7).

The DOD was directed by Congress to review its current policy for disposal of NDS material and determine whether the NDS was properly configured to assure future availability of materials for defense needs in light of current world market conditions. A DOD working group concluded that DNSC's current disposal policy required revision and that the NDS should be reconfigured into a Strategic Material Security Program to encompass the full range of responsibilities required to develop an integrated and comprehensive approach to strategic materials management. The working group supported DNSC's recommendation to temporarily suspend or limit the sale of 13 materials that had no viable substitutes and on which the United States was wholly or substantially import dependent or at a significant risk of supply disruption. Sales of tungsten materials were curtailed to hold a goal quantity equivalent to 1 year's AMP (U.S. Department of Defense, 2010, p. 1–2).

The U.S. Fish and Wildlife Service (FWS) granted final approval to a new class of tungsten shot products for hunting waterfowl and coots. Approval of the tungsten-iron-fluoropolymer products brought the number of FWS-approved tungsten-based shot products to 10. The other nine products were tungsten bronze, tungsten-iron, tungsten-iron-copper-nickel, tungsten matrix (a tungsten-polymer composite), tungsten-nickel-iron, tungsten polymer, tungsten-tin-bismuth, tungsten-tin-iron, and tungsten-tin-iron-nickel (U.S. Fish and Wildlife Service, 2009).

Production

Domestic production statistics for tungsten are based on data collected by the U.S. Geological Survey (USGS) by means of two separate voluntary surveys. Statistics that result from these surveys are listed in tables 1 and 3. The annual "Tungsten Ore and Concentrate Survey" covered the production, purchase, disposition, and stocks of tungsten ores and concentrates.

In 2009, Curtis Tungsten, Inc. (Upland, CA) produced and shipped concentrates from the Andrew Mine in California. EMC Metals Corp. (Vancouver, British Columbia, Canada) maintained its Springer complex in Pershing County, NV, on care-and-maintenance status pending a sustained improvement in tungsten prices. The complex comprised an underground scheelite mine, a mill, and a processing plant designed to produce either ammonium paratungstate (APT) or calcium tungstate (also known as synthetic scheelite). During the year, EMC Metals continued metallurgical testwork to optimize its milling process. EMC Metals had all the permits it needed to complete construction and begin operations at Springer. The company planned to obtain financing to complete mine and mill rehabilitation, and estimated that operations could start within 6 to 8 months of a decision to proceed (EMC Metals Corp., 2010, p. 1–3).

The USGS monthly "Tungsten Concentrate and Tungsten Products Survey" canvassed companies that produced tungsten carbide powder, tungsten chemicals, and (or) tungsten metal powder from APT, tungsten-bearing scrap, and tungsten concentrate. U.S. processors of tungsten materials operating in 2009 are listed in table 4.

In 2009, U.S. processors consumed less APT, scrap, and tungsten concentrates than they did in 2008. Domestic production of APT was lower than that of 2008. Total net production of tungsten metal powder and tungsten carbide powder decreased by 41% in 2009 compared with that of 2008 (table 3).

Consumption

U.S. apparent consumption of all tungsten materials, as calculated from net imports, secondary production, and changes in Government and industry stock levels, was 11,600 t in 2009, 16% lower than the 2008 apparent consumption of 13,800 t. Primary U.S. production was not included in the calculation to avoid disclosing company proprietary data. In 2009, net imports increased as a result of a significant decrease in exports. The increase in net imports was more than offset by decreases in scrap consumption and NDS shipments.

Statistics on consumption of tungsten in end-use applications by U.S. metal consumers were developed from the voluntary "Consolidated Consumers Survey." For this survey, nearly 60 tungsten consumers were canvassed on a monthly or annual basis. Reported consumption and stock data in tables 1 and 5 include estimates to account for nonrespondents.

Total U.S. reported consumption of tungsten materials to make end-use products in 2009 was 39% lower than that of 2008. With the exception of manufacturers of chemical products, tungsten consumption by all industries (steelmakers, producers of cemented carbides, mill products, and superalloys and other alloys) was lower than that of 2008. Compared with consumption in 2008, U.S. end users consumed less ferrotungsten, tungsten carbide powder, tungsten metal powder, and tungsten scrap, but more tungsten chemicals.

Weekly reports of the number of operating drilling rigs give an indication of the demand for tungsten carbide in the form of cemented carbide components used by industry to explore for or produce oil and natural gas. The number of rigs that operated in the United States decreased during the first half of 2009, and then gradually increased during the second half of the year. In 2009, the average of weekly reports of operating rigs in the United States was 1,089, 42% lower than the average of 1,879 operating rigs in 2008 (Baker Hughes Inc., undated).

In 2009, total consumption of tungsten scrap by U.S. processors and consumers was 3,550 t of contained tungsten, which was 26% less than the 4,790 t consumed in 2008.

Prices

APT is the most widely traded primary tungsten material, and as a result, its price has become a reference price for such upstream materials as tungsten ore concentrates and such downstream materials as tungsten metal powder and tungsten carbide powder. Annual average APT prices decreased from those of 2008 (table 1). The U.S. APT price reported by Platts Metals Week decreased twice during the year and ranged from $154 to $182 per short ton unit ($170 to $201 per metric ton unit). U.S. APT prices reported by Metal Bulletin trended downward during the first 11 months of the year, then recovered slightly at yearend. They ranged between $160 and $255 per short ton unit ($176 to $281 per metric ton unit).

Annual average tungsten ore concentrate prices decreased from those of 2008 (table 1). The U.S. spot tungsten ore concentrate prices reported by Platts Metals Week were within the range of $127 to $163 per short ton unit ($140 to $180 per metric ton unit). Platts' annual average ferrotungsten price decreased by 23% to $28.08 per kilogram of contained tungsten in 2009 from $36.60 per kilogram of contained tungsten in 2008. In 2009, the ferrotungsten price ranged between $25.50 and $30 per kilogram.

Foreign Trade

The total tungsten content of U.S. exports was 2,770 t, less than one-half of the 5,980 t exported in 2008. In 2009, the quantity of tungsten in every export category was lower than that of 2008 (tables 6–10).

The total tungsten content of U.S. imports was 10,000 t, 23% less than the 13,100 t imported in 2008. China, which continued to be the leading supplier of imported tungsten to the United States, provided 46% of all tungsten imports in 2009. In 2009, the total tungsten content of imports from China decreased by 19% to 4,580 t from 5,630 t in 2008. The distribution of materials imported from China was as follows: APT, 54%; tungsten carbide powder, 12%; unwrought tungsten, 10%; wrought tungsten, 8%; tungsten oxide, 7%; tungsten waste and scrap, 6%; tungsten metal powders, 3%; and ferrotungsten and other tungstates, minor amounts. Other significant suppliers of tungsten materials were as follows: Bolivia and Canada, which each supplied 9% of the total tungsten imports to the United States; Portugal, 8%; Germany, 6%; and Peru, 4%.

The tungsten contained in U.S. imports of ores and concentrates was 10% lower than that of 2008 (table 11). In 2009, the leading suppliers of U.S. imports of tungsten ores and concentrates were Bolivia (25%), Canada (24%), Portugal (21%), and Peru (12%).

U.S. imports of APT were slightly higher than those of 2008 (table 12). China continued to be the dominant supplier, providing 97% of U.S. APT imports. Imports of other tungsten materials are presented in tables 13–14.

In 2009, U.S. net import reliance for tungsten as a percentage of apparent consumption was 68%. Net import reliance as a percentage of apparent consumption is used to measure the adequacy of current domestic production to meet U.S. demand. Net import reliance was defined as imports minus exports plus adjustments for Government and industry stock changes eleases from stocks, including shipments from the NDS, were ounted as part of import reliance, regardless of whether they ere imported or produced in the United States. Because there as only limited U.S. mine production in 2009, about 68% of .S. tungsten supply was from imports and stock releases, and 2% was from scrap materials generated in the United States.

orld Review

Estimated world tungsten mine production decreased slightly 2009 (table 15). In addition to mine production and tungsten covered from scrap, tungsten materials from the NDS ontributed to supply in 2009.

Australia.—Byproduct tungsten concentrates were produced two mining operations. Tasmania Mines Ltd. (Sydney) oduced a small amount of scheelite concentrate from its Kara pen pit magnetite mine south of Burnie in Tasmania, and Straits esources Ltd. (West Perth) produced a small amount of tungsten oncentrate from its Hillgrove underground gold-antimony mine ear Armidale, New South Wales. In August, Straits suspended roduction to investigate modifications needed to make the plant ommercially viable (Straits Resources Ltd., 2010, p. 6).

Planet Metals Ltd. (formerly Queensland Ores Ltd., Brisbane) vestigated options for preconcentrating run-of-mine ore at its olfram Camp project west of Cairns, Queensland. The open it mine and mill were placed on care-and-maintenance status in ovember 2008 to conserve cash and address metallurgical issues. he operation had been expected to produce approximately 330 etric tons per year (t/yr) of tungsten in wolframite concentrate nd 100 t/yr of molybdenum in molybdenite concentrate at full roduction (Planet Metals Ltd., 2010).

King Island Scheelite Ltd. (Sydney) and Hunan Nonferrous etals Corp. Ltd. (Changsha, China) reevaluated their plan to edevelop the former King Island Scheelite Mine at Grassy, ing Island, northwest of Tasmania. The 50-50 Dolphin Joint enture (DJV) originally planned to redevelop the Dolphin pen pit and process 600,000 t/yr of ore to produce scheelite oncentrates containing approximately 2,400 t/yr of tungsten uring a period of at least 10 years. DJV was considering a maller open pit combined with an underground mine at Dolphin n conjunction with redeveloping a scheelite resource at Bold ead, and an alternate plan that did not include an open pit mine t Dolphin (King Island Scheelite Ltd., 2010).

Vital Metals Ltd. (Subiaco) almost finished a feasibility study n developing an open pit mine and beneficiation plant at the atershed tungsten deposit northwest of Cairns, Queensland. In esponse to economic conditions, Vital reduced its activity at the roject to monitoring and compiling environmental data. The ompany indicated that a 25% increase in the price of tungsten as needed for the project to be profitable (Vital Metals Ltd., 009, p. 2–3; Carr, 2010, p. 15).

Thor Mining PLC (London, United Kingdom) investigated lternatives to reduce capital and operating costs for its Molyhil ungsten-molybdenum project. As initially proposed, the open it mine and mill, to be constructed northeast of Alice Springs n the Northern Territory, was to produce an average of 975 t/yr f tungsten in scheelite concentrate and 390 t/yr of molybdenum n molybdenite concentrate during a 5.7-year life. In November, hor decided to reduce activity on the project until molybdenum and tungsten prices recovered to levels that would support project development (Thor Mining PLC, 2010).

Austria.—Sandvik AB (Sandviken, Sweden), a tool, material, and machinery manufacturer, purchased Wolfram Bergbau und Hütten AG (St. Martin). Wolfram's assets included the Mittersill scheelite mine and mill in the State of Salzburg and the Bergla tungsten processing plant and a tungsten recycling unit near St. Martin in the State of Steiermark (Sandvik AB, 2010, p. 9, 82).

Brazil.—Largo Resources Ltd. (Toronto, Ontario, Canada) signed option agreements to acquire tailings deposited intermittently since the 1940s by the Barra Verde and Boca de Laje tungsten-molybdenum mines west-southwest of Natal, Rio Grande do Norte State. Largo began the Currais Novos project, which would reprocess tailings to recover approximately 830 t/yr of tungsten and 300 t/yr of molybdenum (Largo Resources Ltd., 2010, p. 3, 13).

Canada.—In mid-October, in response to weak demand, low tungsten prices, and increasing inventories of tungsten concentrates and primary materials, North American Tungsten Corp. Ltd. (Vancouver) suspended operations at its Cantung Mine in the Northwest Territories and placed the mine on care-and-maintenance status. As a result, 2009 production of tungsten in scheelite concentrates decreased by 14% compared with that of 2008. North American Tungsten sold concentrates and APT and tungsten blue oxide converted from its concentrates under tolling arrangements. During the suspension, the company evaluated its mining methods, tested new mill processing technologies, and evaluated new capital equipment with the objective of enhancing productivity and reducing operating costs. North American Tungsten planned to restart operations after tungsten prices returned to profitable levels and it had secured offtake agreements for all of its concentrates (North American Tungsten Corp. Ltd., 2010a, p. 10; 2010c, p. 4, 12–13).

North American Tungsten completed the work required for an updated feasibility study on developing its Mactung scheelite deposit in the Yukon. The study indicated that 5,930 t/yr of tungsten in concentrate (748,000 metric ton units per year) could be produced during the first 5 years of production from an underground mine. Additional exploration by North American Tungsten defined an area of near-surface, lower grade ore that could be mined by open pit methods, and which would add 17 years of production to the original 11-year mine life. Construction of the underground mine and mill was expected to take 27 months (North American Tungsten Corp. Ltd., 2010c, p. 3).

During the first quarter of 2009, in response to a decline in tungsten demand, H.C. Starck GmbH (Goslar, Germany) announced that it planned to suspend the expansion of its tungsten plant in Sarnia, Ontario, until economic conditions improved. The company had requested approval from the Ontario Ministry of the Environment for a manufacturing facility with a capacity to produce 4,500 t/yr of metal powder, including tungsten metal, tungsten carbide, and cast tungsten carbide powders. By yearend, H.C. Starck reportedly was considering restarting the expansion (H.C. Starck GmbH, 2009a; Ontario Ministry of the Environment, 2009; The Observer, 2009).

China.—China's Government had a program to conserve its tungsten resources and to try to stabilize tungsten prices. In the mining sector, the Government regulated the production of tungsten concentrates by forbidding foreign investment in tungsten exploration and mining; closing mines that did not meet certain energy, environmental, production, and safety standards; imposing a resource tax on tungsten ores; not issuing new exploration and mining licenses; and setting production quotas. For 2009, the tungsten concentrate production quota was increased by 3% to 68,555 t (65% WO_3). Concentrates recovered from gangue were to be 12% of the quota, and the remaining production was to be distributed by province or autonomous region as follows: Jiangxi (47%), Hunan (21%), Yunnan (5%), Guangdong (4%), Fujian (3%), Gansu, Guangxi, and Inner Mongolia (2% each), Anhui (1%), Zhejiang (0.4%), and Qinghai (0.1%). Local entities, such as the Ganzhou City Government (Jiangxi Province) and the Ganzhou Tungsten Industry Association (GTIA), also regulated the production and marketing of tungsten, including GTIA's monthly recommended prices for tungsten concentrates. In 2009, the Chinese Government encouraged local governments to provide inexpensive financing in exchange for tungsten concentrates and products to help producers maintain cash flow and support tungsten prices (Zhang, 2007; Huang, 2008; Beijing Antaike Information Development Co., Ltd., 2009b; 2010b; Ganzhou Government Online, 2009; Huang, 2009; Metal Bulletin, 2009).

In the processing sector, the Government encouraged the recovery of tungsten from low-grade ores, mixed scheelite-wolframite concentrates, and scrap; banned tolling of tungsten concentrate; limited foreign investment in processing plants; and maintained requirements to limit the building or expansion of plants. These requirements included minimum capacities, the ability to secure reliable supplies of raw materials, the use of the company's own funds for 50% or more of the investment, and meeting environmental, energy, production, and safety standards (Beijing Antaike Information Development Co., Ltd., 2006; Fu, 2007; Zhang, 2007; Huang, 2008, 2009).

With respect to trade, the Government regulated tungsten exports by restricting the volumes and types of materials and products that could be sent out of the country, limiting the number of producers and traders authorized to export tungsten materials and products, and adjusting the export tax system. The 2009 export quota for tungsten materials was reduced to 14,600 t of contained tungsten. To qualify for an export license, companies were required to have minimum production capacities and recycling rates. In response to the global economic downturn and reduced demand from overseas, in 2009, the Chinese Government decreased export taxes on tungstates and tungsten oxides (Ryan's Notes, 2007; Beijing Antaike Information Development Co., Ltd., 2009a; Huang, 2009).

In spite of its position as the world's leading miner of tungsten, China has imported tungsten concentrates in recent years. In 2009, China imported an estimated 4,700 t of tungsten in concentrates. Chinese companies were involved in tungsten mine projects in Australia and Rwanda. In addition, China planned to add tungsten to its strategic stockpile (Beijing Antaike Information Development Co., Ltd., 2009c; 2010a; Ryan's Notes, 2009a).

Germany.—H.C. Starck increased the production capacity at its Goslar plant for ammonium metatungstate and sodium tungstate, which are compounds used by the chemical industry to produce catalysts and other products. The company also expanded its recycling of tungsten materials to include spent catalysts, production wastes, and other tungsten-containing materials from the chemical industry (H.C. Starck GmbH, 2009b).

Japan.—The Ministry of Economy, Trade and Industry (METI) planned to reduce Japan's dependence on China for its supply of tungsten raw materials. METI's strategy comprised providing assistance to develop new mine production in other countries, increasing recycling rates, promoting research to reduce consumption by increasing the life of tungsten products or developing substitutes, and making improvements to the stockpiling program. As part of the strategy, Japan Oil, Gas and Metals National Corp. (JOGMEC) reportedly held tenders to purchase APT and ferrotungsten for the national rare metals stockpile; results of the tenders were not released (Ryan's Notes, 2009b).

Korea, Republic of.—The Korean Government reportedly planned to invest in developing the country's rare metals production industry during a 9-year period and to secure a strategic stockpile of various metals, including tungsten, by 2015 (Asia Pulse Data Source, 2009).

Peru.—In the Ancash region, Malaga Inc. (Montreal, Quebec, Canada) produced tungsten concentrate from the Pasto Bueno mine and mill; the concentrate was sold to U.S. tungsten processor Global Tungsten & Powders Corp. (GTP) under an offtake agreement. Malaga planned to increase its mill capacity to 500 metric tons per day (t/day) of ore by mid-2010 and then to 600 t/day by yearend. The company continued exploration and development work for new sources of ore to support the increased production (Malaga Inc., 2010, p. 3, 6).

Portugal.—Sojitz Beralt Tin and Wolfram (Portugal) S.A. (Barroca Grande) produced wolframite concentrates from the Panasqueira Mine and beneficiation plant in central Portugal. Sojitz planned to increase production from the mine to 1,500 t/yr of tungsten by the fiscal year ending March 31, 2010 (Sojitz Corp., 2008, p. 19; 2009, p. 72).

Russia.—In recent years, tungsten concentrates had been produced by more than five companies in Russia. The companies, with the locations of their operations and listed in order of their share of 2008 Russian production, were as follows: JSC A&IR Mining, which produced concentrates from ores mined by Primorsky GOK in Primorskiy Kray; prospectors cooperative Artel Quartz Ltd. and ZAO Novoorlovsky GOK, both in Zabaykal'sk Kray (formerly Chita Oblast); JSC Lermontovskaya GRK in Primorskiy Kray; Kalgutinskoe Rudoupravlenie Ltd. in Altai Kray; and various prospectors. Scheelite concentrates were produced from Primorskiy Kray, and wolframite concentrates were produced from other areas. In addition to tungsten concentrates, Russian processors consumed approximately 1,500 t/yr to 2,000 t/yr of tungsten scrap (Makulov, 2008; Gorbachev, 2009, p. 8).

In an October auction, KGUP Primteploenergo won the exploration and mining license to the Lermontov Mine in Primorskiy Kray. By yearend, the new owner reportedly had purchased new equipment and restarted production from the mine and beneficiation plant. Operations at Lermontov had been idled for about 1 year (Interfax Ltd., 2009; Itar-Tass News Agency, 2009).

In 2009, Wolfram Company CJSC stated that it was building a fractory metals plant in Unecha, Bryansk Oblast, and searching r strategic investors for the redevelopment of the Tyrnyauz ngsten-molybdenum mining complex in Kabardino-Balkariya public and the development of the Kholtoson and Inkurskoe posits in Buryatiya Republic (Gorbachev, 2009, p. 17–18).

Rwanda.—Xiamen Tungsten Co., Ltd. (Xiamen, China) ansported equipment to its tungsten mine site. The company as developing the resource to ensure a supply of raw materials r its production of tungsten products in China (Beijing Antaike formation Development Co., Ltd., 2009c).

Spain.—Heemskirk Consolidated Ltd. (Melbourne, Australia) orked to reconfigure its milling process to improve throughput nd tungsten recovery from the Los Santos tungsten mine in e Castilla y Leon region. The company aimed to increase its nual output to between 90,000 metric ton units and 100,000 etric ton units (between 714 t/yr of tungsten and 793 t/yr tungsten). All of the scheelite concentrate produced was ommitted to GTP under a 6-year offtake agreement (Heemskirk onsolidated Ltd., 2010a; b, p. 14).

United Kingdom.—Wolf Minerals Ltd. (Subiaco, Australia) udied the feasibility of redeveloping the Hemerdon Ball ngsten and tin project northeast of Plymouth in southwestern ngland. The open pit mine and milling operation was pected to produce approximately 360,000 metric ton units r year (2,850 t/yr of tungsten) in wolframite concentrate nd 500 t/yr of tin in concentrate for 12 years. As part of an quity placement, Wolf Minerals signed a memorandum of nderstanding with Traxys Europe S.A. to market 100% of the ngsten concentrates and an offtake agreement for 100% of e tin concentrates from the project. Wolf Minerals planned begin construction in 2010, mining in 2011, and concentrate roduction in 2012 (Wolf Minerals Ltd., 2009; 2010, p. 10, 13).

Vietnam.—Vietnam Youngsun Tungsten Industry Co., Ltd. roduced ferrotungsten in Halong City, Quang Ninh Province. ost of the production was from scheelite and wolframite res purchased from Thienke tungsten mine in Tuyen Quang rovince and Philieng tungsten mine in Lam Dong Province. he ferrotungsten was produced for export to Europe, Japan, epublic of Korea, and the United States (Vietnam Youngsun ungsten Industry Co., Ltd., 2009a, b).

Tiberon Minerals Ltd. (Toronto, Ontario, Canada) and its oint-venture partners sought funding to develop the Nui Phao roject in Thai Nguyen Province. The project comprised an open it mine and mill to produce an estimated 3,800 t/yr of tungsten n concentrate as well as copper and fluorspar concentrates and ismuth cement during an expected mine life of more than 16 years. he Government of Vietnam informed Tiberon that it would revoke ts mining license if the mine was not brought into production by ovember 2010 (Dragon Capital Markets Ltd., 2010).

utlook

Tungsten use is strongly influenced by general economic onditions. Future consumption of tungsten in cemented arbides, which is the leading end-use sector, will depend on the erformance of the following industries: automotive and aircraft roduction; construction; electronics manufacturing, where emented carbide microdrills are used on circuit boards; general manufacturing; large equipment manufacturing; mining; and oil and gas drilling. Tungsten use is also influenced by Government spending for defense applications. Economic conditions improved during the latter half of 2009 and into 2010, and tungsten consumption increased (Garrity, 2010, p. 3, 12, 37; Greaves, 2010, p. 8, 15, 17; Nishino, 2010, p. 11–17, 21).

World tungsten supply will continue to be dominated by Chinese production and exports. The Chinese tungsten concentrate production quota for 2010 was increased by 17% to 80,000 t (65% WO_3). Export licenses for 2010 were limited to 14,300 t of all tungsten products, a decrease of 2% from the quota of 14,600 t in 2009. In mid-July 2010, the Chinese Government canceled export tax rebates for certain materials, including some tungsten products (Beijing Antaike Information Development Co., Ltd., 2009a, 2010b; Ryan's Notes, 2010).

By mid-2010, North American Tungsten's inventories of excess tungsten concentrates had been sold and the company planned to restart production from its Cantung Mine in Northwest Territories, Canada (North American Tungsten Corp. Ltd., 2010b).

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TABLE 1
SALIENT TUNGSTEN STATISTICS[1]

(Metric tons of tungsten content and dollars per metric ton unit)

	2005	2006	2007	2008	2009
United States:					
Concentrates:					
Production	--	--	W	W	W
Consumption	W	W	W	W	W
Exports	52	130	109	496	38
Imports for consumption	2,080	2,290	3,880	3,990	3,590
Stocks, December 31:					
Consumer	W	W	W	W	W
U.S. Government[2]	26,100	22,900	21,200	19,700	19,000
Price:					
U.S. spot quotation[3]	146	200	189	184	151
European[4]	123	166	165	164	150
Ammonium paratungstate:					
Production	W	W	W	W	W
Consumption[5]	9,530	11,300	12,000	9,700	6,860
Stocks, December 31, producer and consumer	W	W	68	W	100
Price:					
U.S. free market[6]	237	293	284	278	204
U.S. market[3]	240	273	262	260	178
European free market[6]	223	261	248	249	203
Primary products:					
Net production[7]	7,810	8,050	8,360	8,950	5,300
Consumption[8]	11,100	12,300	11,300	11,900	7,290
Stocks, December 31:					
Producer[9]	800	827	825	707	682
Consumer[8]	508	450	481	528	491
U.S. Government[2]	282	266	235	183	171
World, production of concentrate	59,500	56,400 [r]	54,100	62,200 [r]	61,300 [e]

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Defense National Stockpile Center. Data through 2006 include material committed for sale pending shipment; data for 2007–09 are uncommitted material only.

[3] Annual average calculated from weekly prices reported by Platts Metals Week.

[4] Annual average calculated from semiweekly prices reported by Metal Bulletin.

[5] Reported by tungsten processors.

[6] Annual average calculated from annual average high and low prices reported by Metal Bulletin for 2005–06 and from semiweekly prices reported by Metal Bulletin for 2007–09.

[7] Includes only tungsten metal powder and tungsten carbide powder.

[8] Includes ammonium paratungstate and other tungsten chemicals, ferrotungsten, tungsten metal powder, tungsten carbide powder, and tungsten scrap.

[9] Data exclude cast and crystalline tungsten carbide powder and chemicals.

TABLE 2

U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE TUNGSTEN STATISTICS IN 2009[1, 2]

(Metric tons of tungsten content)

	Inventory, yearend[3]		Annual	Sales		Inventory decrease[4]	
Material	Fiscal year[5]	Calendar year	Materials Plan[5]	Fiscal year[5]	Calendar year	Fiscal year[5]	Calendar year
Ores and concentrates	19,700	19,000	3,630	250	762	175	688
Tungsten metal powder	172	171	136	11	11	11	12
Total	19,800	19,200	3,760	261	773	187	700

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes stockpile- and nonstockpile-grade materials.

[3] Uncommitted inventory only. Does not include material committed for sale pending shipment.

[4] From previous year. Based solely on uncommitted yearend inventories.

[5] Twelve-month period ending September 30, 2009.

Source: Defense National Stockpile Center.

TABLE 3

U.S. NET PRODUCTION AND STOCKS OF TUNGSTEN PRODUCTS[1, 2, 3]

(Metric tons of tungsten content)

	Tungsten metal powder	Tungsten carbide powder	Total
Net production:			
2008	4,230	4,720	8,950
2009	2,880	2,420	5,300
Producer stocks:			
December 31, 2008	377	330	707
December 31, 2009	379	304	682

[1] Net production equals receipts plus gross production less quantity used to make other products in table.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Data for cast and crystalline tungsten carbide powder and tungsten chemicals are withheld to avoid disclosing company proprietary data; not included in "Total."

TABLE 4

U.S. PROCESSORS OF TUNGSTEN IN 2009[1]

Company	Plant location
ATI Alldyne[2]	Huntsville, AL.
Buffalo Tungsten Inc.	Depew, NY.
Chem-Met Co., The	Clinton, MD.
Elmet Technologies, Inc.	Lewiston, ME.
General Electric Co.	Euclid, OH.
Global Tungsten & Powders Corp.[3]	Towanda, PA.
Kennametal Inc.	Fallon, NV.
Do.	Latrobe, PA.
Tungsten Diversified Industries LLC[4]	White Bear Lake, MN.[5]

Do. Ditto

[1] Consumers of ammonium paratungstate, tungsten-bearing scrap, tungsten concentrates, and (or) tungsten oxides.

[2] An Allegheny Technologies Inc. company.

[3] A division of Plansee Group; formerly owned by Osram Sylvania Inc.

[4] Joint venture of North American Tungsten Corp. Ltd., Tundra Particle Technologies LLC, and Queenwood Capital Partners LLC.

[5] Pilot-scale operation.

TABLE 5

U.S. REPORTED CONSUMPTION AND STOCKS OF TUNGSTEN PRODUCTS[1, 2, 3]

(Metric tons of tungsten content)

	2008	2009
Consumption by end use:		
Steels	283	244
Superalloys	W	399
Other alloys[4]	W	W
Cemented carbides[5]	6,650	4,070
Mill products made from metal powder	W	W
Chemical uses	80	84
Total	11,900	7,290
Consumption by form:		
Ferrotungsten	253	246
Tungsten metal powder	W	2,450
Tungsten carbide powder	6,750	3,980
Tungsten scrap[6]	W	535
Other tungsten materials[7]	80	84
Total	11,900	7,290
Consumer stocks, December 31:		
Ferrotungsten	16	16
Tungsten metal powder	26	27
Tungsten carbide powder	448	387
Tungsten scrap[6]	29	48
Other tungsten materials[7]	10	13
Total	528	491

W Withheld to avoid disclosing company proprietary data; included in "Total."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Does not include materials used in making primary tungsten products.

[3] Includes estimates.

[4] Includes welding and hard-facing rods and materials, wear- and corrosion-resistant alloys, and nonferrous alloys.

[5] Includes diamond tool matrices, cemented and sintered carbides, and cast carbide dies or parts.

[6] Includes tungsten bars.

[7] Includes tungsten chemicals.

TABLE 6

U.S. EXPORTS OF TUNGSTEN ORES AND CONCENTRATES, BY COUNTRY[1]

	2008			2009		
	Quantity			Quantity		
Country of destination	Gross weight (metric tons)	Tungsten content[2] (metric tons)	Value (thousands)	Gross weight (metric tons)	Tungsten content[2] (metric tons)	Value (thousands)
Australia	(3)	(3)	$13	(3)	(3)	$10
Austria	(3)	(3)	3	--	--	--
Belgium	(3)	(3)	5	--	--	--
Brazil	--	--	--	2	1	38
Canada	--	--	--	(3)	(3)	4
China	288	149	4,770	14	7	219
Egypt	--	--	--	4	2	59
Georgia	(3)	(3)	5	--	--	--
Germany	664	343	9,570	1	(3)	15
Ireland	--	--	--	1	1	18
Israel	--	--	--	1	(3)	10
Italy	--	--	--	(3)	(3)	8
Japan	(3)	(3)	4	--	--	--
Korea, Republic of	--	--	--	(3)	(3)	6
Malaysia	2	1	25	8	4	168
Mexico	2	1	26	--	--	--
Singapore	1	(3)	12	--	--	--
Spain	--	--	--	18	9	176
United Kingdom	3	2	67	(3)	(3)	10
Vietnam	--	--	--	24	12	340
Total	961	496	14,500	73	38	1,080

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Content estimated from reported gross weight.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7

U.S. EXPORTS OF AMMONIUM PARATUNGSTATE, BY COUNTRY[1]

	2008		2009	
Country of destination	Quantity, tungsten content (metric tons)	Value (thousands)	Quantity, tungsten content (metric tons)	Value (thousands)
Austria	9	$205	18	$361
France	41	364	--	--
Germany	524	9,090	350	5,560
Hungary	--	--	2	28
India	6	50	1	10
Italy	5	44	2	14
Japan	(2)	3	--	--
Mexico	2	16	2	16
Spain	32	279	--	--
Taiwan	1	9	1	5
Total	621	10,100	375	5,990

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8

U.S. EXPORTS OF TUNGSTEN METAL POWDERS, BY COUNTRY[1,2]

	2008			2009		
	Quantity			Quantity		
Country of destination	Gross weight (metric tons)	Tungsten content[3] (metric tons)	Value (thousands)	Gross weight (metric tons)	Tungsten content[3] (metric tons)	Value (thousands)
Australia	3	2	$278	2	1	$90
Austria	2	1	69	4	3	140
Belgium	4	3	153	--	--	--
Brazil	41	32	2,470	14	11	797
Canada	131	105	5,690	76	61	3,140
Chile	2	2	181	2	2	119
China	17	14	1,210	23	19	1,720
France	25	20	1,990	9	7	743
Germany	368	294	14,300	155	124	9,010
Hong Kong	1	1	64	1	1	31
India	6	4	384	13	10	739
Indonesia	1	(4)	36	2	1	81
Ireland	(4)	(4)	3	4	3	187
Israel	2	1	146	3	2	268
Italy	13	10	966	11	9	1,000
Japan	13	11	1,200	10	8	922
Korea, Republic of	3	3	262	5	4	403
Mexico	437	350	17,800	14	12	629
Netherlands	10	8	215	25	20	765
Peru	6	5	271	2	2	133
Russia	2	2	78	--	--	--
Singapore	46	37	2,590	18	14	1,610
South Africa	2	1	133	2	2	126
Spain	2	2	153	--	--	--
Switzerland	8	6	561	2	2	187
Taiwan	32	26	1,760	12	10	849
Turkey	4	3	357	2	2	129
United Arab Emirates	6	5	535	3	2	248
United Kingdom	27	22	2,470	15	12	969
Venezuela	4	3	219	1	1	71
Vietnam	--	--	--	18	14	260
Other	9	7	473 [r]	3	2	154
Total	1,230	981	57,100	450	360	25,500

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] May include tungsten alloy powders.

[3] Content estimated from reported gross weight.

[4] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9

U.S. EXPORTS OF TUNGSTEN CARBIDE POWDER, BY COUNTRY[1]

	2008		2009	
Country of destination	Quantity, tungsten content (metric tons)	Value (thousands)	Quantity, tungsten content (metric tons)	Value (thousands)
Argentina	(2)	$21	3	$56
Australia	26	1,040	18	404
Austria	150	6,130	42	1,010
Belgium	17	814	2	234
Brazil	10	301	12	456
Canada	101	5,610	62	2,930
China	6	387	3	241
Cyprus	--	--	3	95
France	173	5,060	7	476
Germany	336	16,000	125	6,080
Hong Kong	4	143	2	181
India	17	612	4	142
Ireland	26	843	26	773
Israel	20	368	(2)	9
Italy	6	264	(2)	12
Japan	23	994	8	253
Korea, Republic of	4	241	3	160
Malaysia	1	66	6	212
Mexico	5	395	2	130
Norway	1	68	3	105
Poland	(2)	3	13	667
Singapore	5	363	9	380
South Africa	18	514	30	1,070
Switzerland	4	233	(2)	12
Taiwan	79	3,030	32	1,180
United Kingdom	236	7,670	38	1,280
Venezuela	56	1,310	7	402
Other	11 r	863 r	10	687
Total	1,340	53,300	469	19,600

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 10

U.S. EXPORTS OF MISCELLANEOUS TUNGSTEN-BEARING MATERIALS, BY COUNTRY[1]

	2008		2009	
Product and country of destination	Quantity, tungsten content (metric tons)	Value (thousands)	Quantity, tungsten content (metric tons)	Value (thousands)
Ferrotungsten and ferrosilicon tungsten:				
Canada	--	--	1	$24
India	9	$20	--	--
Mexico	2	107	1	26
United Kingdom	--	--	(2)	4
Total	10	127	1	55
Unwrought tungsten:[3, 4, 5]				
Austria	8	34	14	121
Brazil	19	86	5	34
Canada	133	861	56	467
Chile	4	16	7	29
China	24	211	24	100
Czech Republic	--	--	17	70
France	--	--	38	162
Germany	75	321	16	73
Hong Kong	--	--	6	24
Hungary	16	76	18	85
India	12	52	--	--
Israel	5	100	1	3
Japan	16	68	(2)	12
Malaysia	5	22	5	22
Mexico	13	61	6	25
New Zealand	7	29	(2)	6
Philippines	5	110	8	36
Singapore	12	58	14	69
Taiwan	32	139	7	45
United Kingdom	29	123	27	113
Venezuela	6	23	--	--
Other	8 r	45 r	9	41
Total	429	2,430	277	1,530
Waste and scrap:[4]				
Afghanistan	8	34	--	--
Belgium	40	657	--	--
Canada	119	1,080	29	341
China	222	8,050	181	3,290
Finland	--	--	61	1,500
Germany	432	9,640	190	3,080
Hong Kong	32	557	--	--
India	131	1,040	32	703
Israel	--	--	6	82
Japan	164	3,960	19	159
Malaysia	33	280	212	1,790
Mexico	9	82	1	11
Netherlands	68	762	17	141
Philippines	--	--	5	41
Singapore	6	48	1	8

See footnotes at end of table.

TABLE 10—Continued

U.S. EXPORTS OF MISCELLANEOUS TUNGSTEN-BEARING MATERIALS, BY COUNTRY[1]

Product and country of destination	2008 Quantity, tungsten content (metric tons)	2008 Value (thousands)	2009 Quantity, tungsten content (metric tons)	2009 Value (thousands)
Waste and scrap—Continued:[4]				
South Africa	1	$20	6	$71
Taiwan	--	--	31	558
United Arab Emirates	15	83	--	--
United Kingdom	369	3,420	181	1,570
Other	5 r	71 r	9	80
Total	1,650	29,800	981	13,400
Wrought tungsten:[3, 4, 6]				
Australia	9	1,510	6	1,170
Brazil	12	1,480	6	597
Canada	34	3,420	24	2,540
China	10	1,720	5	944
Colombia	3	481	2	369
Czech Republic	20	2,730	16	2,240
France	2	186	4	320
Germany	92	8,650	35	5,070
Hungary	6	1,130	3	579
India	2	244	3	260
Indonesia	3	372	3	797
Israel	9	2,470	(2)	35
Italy	7	1,810	2	451
Japan	55	10,400	25	5,640
Mexico	20	3,520	17	3,090
Netherlands	21	1,530	3	787
Spain	6	602	3	473
Sweden	4	1,340	7	1,860
United Kingdom	25	4,660	19	3,440
Other	16 r	2,410 r	17	2,380
Total	357	50,600	198	33,000
Tungsten compounds:[7]				
Canada	23	82	25	84
Ireland	36	1,080	2	44
Mexico	33	41	21	18
Netherlands	1	15	19	329
Other	(2)	8	1	75
Total	92	1,230	67	551

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

[3] May include alloys.

[4] Content estimated from reported gross weight.

[5] Includes bars and rods produced simply by sintering; excludes powders and waste and scrap.

[6] Includes bars and rods other than those produced simply by sintering; profiles, plates, sheets, strip, and foil; wire; and other wrought products.

[7] Includes only other tungstates.

Source: U.S. Census Bureau.

TABLE 11

U.S. IMPORTS FOR CONSUMPTION OF TUNGSTEN ORES AND CONCENTRATES, BY COUNTRY[1]

	2008		2009	
Country of origin	Quantity, tungsten content (metric tons)	Value (thousands)	Quantity, tungsten content (metric tons)	Value (thousands)
Bolivia	1,100	$24,800	891	$16,800
Brazil	170	4,220	14	233
Canada	963	22,800	856	17,500
China	11	471	--	--
Guatemala	--	--	8	28
Kenya	13	281	20	356
Mexico	13	140	22	191
Mongolia	51	829	35	476
Peru	401	10,100	427	9,160
Portugal	836	23,100	756	18,100
Rwanda	113	2,190	216	3,470
Spain	147	4,000	196	4,250
Thailand	147	2,140	115	1,830
Uganda	30	790	12	245
United Kingdom	--	--	18	275
Total	3,990	95,900	3,590	72,900

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 12

U.S. IMPORTS FOR CONSUMPTION OF AMMONIUM PARATUNGSTATE, BY COUNTRY[1]

	2008		2009	
Country of origin	Quantity, tungsten content (metric tons)	Value (thousands)	Quantity, tungsten content (metric tons)	Value (thousands)
China	2,430	$64,300	2,470	$51,000
Germany	81	2,470	47	1,020
United Kingdom	--	--	(2)	11
Vietnam	--	--	25	553
Total	2,510	66,700	2,540	52,600

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 13

U.S. IMPORTS FOR CONSUMPTION OF FERROTUNGSTEN AND FERROSILICON TUNGSTEN, BY COUNTRY[1]

	2008		2009	
Country of origin	Quantity, tungsten content (metric tons)	Value (thousands)	Quantity, tungsten content (metric tons)	Value (thousands)
China	286	$9,690	23	$624
Hong Kong	15	568	--	--
Sweden	8	288	--	--
Vietnam	--	--	23	641
Total	309	10,500	46	1,260

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 14

U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS TUNGSTEN-BEARING MATERIALS, BY COUNTRY[1]

	2008		2009	
Product and country of origin	Quantity, tungsten content (metric tons)	Value (thousands)	Quantity, tungsten content (metric tons)	Value (thousands)
Tungsten metal powders:[2]				
Canada	72	$2,620	20	$864
China	177	6,650	133	4,320
Czech Republic	14	575	(3)	19
Germany	318	14,100	255	9,720
Israel	371	16,100	211	9,140
Japan	24	1,180	27	1,220
Korea, Republic of	199	8,570	187	6,960
United Kingdom	(3)	10	2	55
Other	(3)	24 r	2	121
Total	1,180	49,800	837	32,400
Tungsten carbide powder:				
Austria	1	56	6	114
Belgium	2	212	5	304
Canada	306	12,500	26	1,250
China	796	29,500	536	16,500
Czech Republic	9	525	23	904
France	2	159	4	351
Germany	172	11,700	54	4,270
Hong Kong	28	1,160	8	183
India	7	333	3	85
Israel	96	3,960	43	1,680
Korea, Republic of	18	807	12	494
Sweden	168	6,110	32	1,130
Other	(3) r	35 r	1	77
Total	1,600	67,100	753	27,400

See footnotes at end of table.

TABLE 14—Continued
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS TUNGSTEN-BEARING MATERIALS, BY COUNTRY[1]

	2008		2009	
Product and country of origin	Quantity, tungsten content (metric tons)	Value (thousands)	Quantity, tungsten content (metric tons)	Value (thousands)
Unwrought tungsten:[2,4,5]				
China	517	$17,500	475	$12,000
Germany	13	1,220	3	229
Netherlands	19	644	--	--
Singapore	16	291	14	459
United Kingdom	7	142	(3)	38
Vietnam	10	314	--	--
Other	(3)	45 r	(3)	33
Total	581	20,200	492	12,800
Waste and scrap:				
Australia	16	311	--	--
Austria	(3)	19	69	937
Brazil	10	98	--	--
Canada	19	413	14	194
Chile	10	173	1	16
China	179	5,490	252	6,250
Czech Republic	21	231	4	84
Germany	382	7,520	215	3,110
Hong Kong	15	505	9	197
India	31	657	8	47
Israel	53	536	32	360
Japan	22	472	19	377
Korea, Republic of	85	1,160	65	609
Mexico	185	1,870	74	757
Pakistan	29	752	2	21
South Africa	14	216	(3)	5
Sweden	36	823	40	541
Taiwan	--	--	7	40
Thailand	122	1,280	8	97
United Kingdom	19	451	56	937
Other	27 r	696 r	3	113
Total	1,270	23,700	879	14,700
Wrought tungsten:[2,4,6]				
Austria	26	4,750	29	4,670
Belgium	7	1,090	7	967
China	539	27,600	364	15,500
Czech Republic	4	2,600	8	6,050
France	6	1,120	6	1,260
Germany	37	3,490	5	938
Hong Kong	25	1,280	4	308
Hungary	3	682	3	648
Israel	14	2,010	1	191
Japan	21	4,760	16	4,090
Netherlands	11	1,050	4	842
Russia	5	601	1	73
South Africa	21	665	3	81
Vietnam	--	--	5	119
Other	12 r	2,930 r	7	1,780
Total	731	54,700	462	37,500

See footnotes at end of table.

TABLE 14—Continued

U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS TUNGSTEN-BEARING MATERIALS, BY COUNTRY[1]

Product and country of origin	2008		2009	
	Quantity, tungsten content (metric tons)	Value (thousands)	Quantity, tungsten content (metric tons)	Value (thousands)
Tungsten oxides:				
China	676	$19,800	329	$8,170
Germany	17	445	5	167
Hong Kong	16	569	--	--
Japan	26	904	12	403
Netherlands	--	--	14	324
Russia	66	1,890	16	342
Vietnam	--	--	5	85
Other	(3)	16	--	--
Total	801	23,600	380	9,490
Other tungstates:				
China	15	430	1	30
India	36	1,050	4	112
Ireland	3	17	5	23
Italy	--	--	2	17
Japan	(3)	3	4	38
Other	(3)	82 r	1	135
Total	55	1,590	17	356
Other tungsten compounds:[7]				
Germany	8	180	3	159
Japan	4	943	1	392
Total	12	1,120	5	550

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] May include alloys.

[3] Less than ½ unit.

[4] Content estimated from reported gross weight.

[5] Includes bars and rods produced simply by sintering; excludes powders and waste and scrap.

[6] Includes bars and rods other than those produced simply by sintering; foil, plates, profiles, sheets, and strip; wire; and other wrought products.

[7] Includes tungsten chlorides.

Source: U.S. Census Bureau.

TABLE 15
TUNGSTEN: WORLD CONCENTRATE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, tungsten content)

Country[3]	2005	2006	2007	2008	2009[e]
Australia	7	15	7	28	33
Austria	1,280	1,153	1,117	1,122	900
Bolivia	531	868	1,107	1,148	1,023 [4]
Brazil	577	525	537	408 [r]	500
Burma[5]	168	197	183	136 [r]	87 [4]
Burundi	94	238	144	194	190
Canada	384	1,983	2,305	2,277	1,964 [4]
China[e, 6]	51,200	45,000	41,000	50,000 [r]	51,000
Congo (Kinshasa)[e]	180	500	570	340	170
Korea, North[e, 7]	650	930 [r]	230 [r]	270 [r]	100
Mongolia	78	182 [r]	245	142	39 [4]
Peru	--	50	366	456	502 [4]
Portugal	816	780	846	900 [r]	900
Russia[e]	2,800	2,800	3,300	3,000	2,500
Rwanda	318	820	1,534	975	499 [4]
Spain[e]	--	--	--	150	260
Thailand[e]	345	303	477	617 [r]	600
Uganda	36	75	86 [r]	50 [r, e]	20
United States	--	--	W	W	W
Total	59,500	56,400 [r]	54,100	62,200 [r]	61,300

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 22, 2010.

[3] Tungsten concentrates are thought to be produced in Mexico, Nigeria, Turkey, and Vietnam, and may be produced from tin-tungsten ores in Kyrgyzstan, but information is inadequate to make reliable estimates of production. Illegal tungsten (wolfram) mining in the Phuoc Trung Commune of the Bac Ai District, Ninh Thuan Province in Southern Vietnam reportedly was halted by the District People's Committee in April 2008.

[4] Reported figure.

[5] Includes tungsten content of tin-tungsten concentrate produced by state-owned mining enterprises under the Ministry of Mines.

[6] Based upon data published in the Yearbook of Nonferrous Metals Industry of China.

[7] Production estimated based on Chinese imports.

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VANADIUM

By Désirée E. Polyak

Domestic survey data and tables were prepared by Barbara J. McNair, statistical assistant, and the world production tables re prepared by Lisa D. Miller, international data coordinator.

In 2009, reported vanadium consumption in the United ates was 5,000 metric tons (t) of contained vanadium, a ght decrease from that of 2008 (table 1). The United States ported 672 t of ferrovanadium (FeV), 401 t of vanadium ntoxide (V_2O_5), and 506 t of other oxides and hydroxides of nadium collectively valued at $25.2 million. Total exports of ese vanadium-bearing materials slightly increased from those 2008. The United States imported (measured in vanadium ntent) 353 t of FeV; 1,100 t of V_2O_5; and 25 t of other oxides d hydroxides of vanadium collectively valued at $29.7 illion. Total imports for consumption of these vanadium aterials decreased by 77% from those of 2008. This decrease attributed to an 87% decrease in FeV imports, a 70% decrease V_2O_5 imports, and an 83% decrease in imports of other oxides d hydroxides.

Vanadium's primary use is as a hardening agent in steel, which it is critical in imparting toughness and wear sistance. These properties are especially important in gh-strength low-alloy steels. Catalysts represented the leading nmetallurgical use for vanadium.

Vanadium recovery from various industrial waste materials, ch as vanadium-bearing fly ash, petroleum residues, pig on slag, and spent catalysts was the leading source of U.S. nadium production. A small amount of vanadium was tained as a coproduct from the mining of uraniferous ndstones on the Colorado Plateau. Fewer than 10 firms, imarily in Arkansas, Ohio, Pennsylvania, and Texas, processed aste materials to produce V_2O_5, FeV, and vanadium metal.

roduction

The major vanadium commodities are aluminum-vanadium aster alloys; FeV; vanadium-bearing ash, residues, and slag; nadium chemicals; and V_2O_5 and other oxides and hydroxides vanadium. In 2009, companies in the United States produced l of these materials with the exception of vanadium-bearing ag from the manufacture of iron and steel. Vanadium-ntaining steels can be subdivided into microalloy or low-alloy eels that generally contain less than 0.15% vanadium and gh-alloy steels that contain as much as 5% vanadium.

Uranium production from carnotite ores creates a nadium-bearing waste solution that must be neutralized have the heavy metals fixed before waste disposal. An ternative treatment is a circuit which extracts vanadium d produces V_2O_5. Denison Mines Corp. (Toronto, Ontario, anada) owns the White Mesa uranium processing mill ear Blanding, UT. It processed feed from Denison's mine operties on the Colorado Plateau as well as uranium/ nadium ores purchased from independent miners. For every 45 kilogram (kg) of triuranium octoxide (yellow cake) oduced, White Mesa's vanadium coproduct recovery circuit produced approximately 1.8 kg of vanadium in the form of V_2O_5. Approximately 554 t of V_2O_5 was produced in 2008, but output in 2009 was less than 230 t of V_2O_5. The mill was idled in May 2009, but was expected to restart in the first half of 2010. At yearend 2009, a total of 174,000 t of conventional ore containing approximately 16,300 t of V_2O_5 was stockpiled at the mill. Inventory available for sale from U.S. production was 350 t of V_2O_5 and 0.9 t of FeV (Denison Mines Corp., 2010, p. 9).

In 2008, U.S. mills consumed slightly more than 0.08 kg of vanadium per ton of steel produced, according to Strategic Minerals Corp. Inc. (Stratcor). This unit consumption was about 14% more than that of steelmakers in Western Europe, which used slightly more than 0.07 kg of vanadium per ton of steel produced. Chinese mills used only about 0.025 kg of vanadium per ton of steel produced (Metal-Pages, 2009e).

Stratcor temporarily shut down vanadium operations at its Hot Springs, AR, and Brits, South Africa, plants in December 2008 because of reduced demand for vanadium products. The Arkansas production facility was reopened at the end of January 2009. The plant was capable of producing approximately 5,400 t of high-purity V_2O_5 but was operating at 60% to 70% of capacity (Metal-Pages, 2009c). The South African operation was reopened at the end of February. In July, the operation was put on extended maintenance until the middle of October. The operation produces FeV and a proprietary nitrided vanadium product, an alloy containing 76% to 81% vanadium. Stratcor markets the product under the name Nitrovan as a replacement for FeV in the steelmaking process (Metal-Pages, 2009d).

Metallurg Vanadium Corp. closed its Cambridge, OH, FeV plant for 6 weeks starting at the end of June owing to the downturn in the world financial markets. According to the company, the plant produced 1,800 metric tons per year (t/yr) of 50% to 60% FeV (Ryan's Notes, 2009b).

Consumption

The U.S. Geological Survey (USGS) derived vanadium consumption data from a voluntary survey of domestic consuming companies. For this survey, more than 80 companies were canvassed on a monthly or annual basis. Based on USGS data, reported domestic vanadium consumption in 2009 was 5,000 t, a slight decrease from that of 2008.

Metallurgical applications continued to dominate U.S. vanadium use in 2009, accounting for 97% of reported consumption. Nonmetallurgical applications included catalysts, ceramics, electronics, and vanadium chemicals. The dominant nonmetallurgical use was in catalysts.

Most vanadium is consumed in the form of FeV, which is used as a means of introducing vanadium into steel, in which it provides additional strength and toughness. FeV is available as alloys containing either 45% to 50%, or 80% vanadium. The

45%- to 50%-grade FeV is produced by silicothermic reduction of V_2O_5 in slag or other vanadium-containing materials. Most of the 80%-grade FeV is produced by aluminothermic reduction of V_2O_5 in the presence of steel scrap or by direct reduction in an electric arc furnace.

Prices

In 2009, the price for domestic FeV, as published in Metal Bulletin, ranged from $7.40 to $35.00 per pound of contained vanadium, compared with $18.00 to $46.00 per pound reported in 2008. In early January, prices were at a high of $35.00 per pound. The price drastically decreased to $18 per pound in mid-January and in mid-February decreased again to $11.75 per pound. Prices continued to gradually decrease to a low of $7.40 per pound in May. Prices gradually increased at the end of May through September but decreased for the remainder of the year to an average of $10.75 per pound in December. The European FeV price ranged from $17.50 to $36.00 per kilogram compared with $26.00 to $93.00 per kilogram in 2008. The European price averaged $26.26 per kilogram in January, gradually decreased to a low of $17.50 per kilogram in May, and increased to a high of $36.00 in late August. The price decreased in September for the remainder of the year to an average of $21.82 per kilogram in December.

The Metal Bulletin published price for domestic V_2O_5 ranged between $3.60 and $7.60 per pound in 2009, compared with $7.20 and $18.40 per pound in 2008. The price averaged about $6.32 per pound in January and decreased to a low of $3.60 per pound in May. Prices increased to an average of $7.28 in September but then gradually decreased in October through December to end the year with an average of $6.91 in December.

World Review

Nearly all the world's supply of vanadium came from primary sources. Five countries recovered vanadium from ores, concentrates, slag, or petroleum residues (table 7). In four of the five countries, the mining and processing of magnetite-bearing ores was an important source of vanadium production. The leading vanadium-producing countries remained China, Russia, and South Africa. Japan and the United States were thought to be the only countries to recover significant quantities of vanadium from petroleum residues.

Recycling of vanadium-containing alloys for recovery of vanadium was negligible and involved mainly a small quantity of tool steel. Vanadium's major end use was as an alloying-element in iron, steel, and titanium-bearing alloys, from which it is lost to slag and not recovered when those metals are recycled. Only small quantities of vanadium were recovered from recycling vanadium-bearing catalysts and that material was reused to make new catalysts.

World vanadium reserves at more than 13 million metric tons (Mt) are sufficient to meet vanadium demand into the next century at the present rate of consumption. Increased recovery of vanadium from fly ash, petroleum residues, slag, and spent catalyst is not taken into account and is expected to extend the life of the reserves significantly. If China increased its vanadium consumption to match the average seen throughout the Western world, vanadium requirements could potentially increase by approximately 52,600 t/yr of V_2O_5 (Denison Mines Corp., [illegible] p. 9).

Australia.—In February, Windimurra Vanadium Ltd. (West Perth) announced that it had been placed in receivership, and its vanadium mine in Western Australia was put on care-and-maintenance status owing to the economic downturn. In late December 2008, Windimurra acknowledged that it needed an additional $81 million for construction labor costs and pushed the operational date back to the second quarter of 2009. Windimurra has been in and out of legal disputes since former owner Xstrata Alloys Ltd. bought a 40% stake from Precious Metals Australia Ltd. and then shut down production in 2004, citing global oversupply (Ryan's Notes, 2009c). The Windimurra vanadium project, owned 90% by Windimurra and 10% by Noble Resources Ltd. (Hong Kong), included an open pit mine, processing plant, and ancillary facilities. When in operation, the mine was expected to produce approximately 5,600 t/yr of contained vanadium (Windimurra Vanadium Ltd., 2008).

Australian junior mining company NiPlats Australia Ltd. (Perth) announced that it completed an initial beneficiation study of a potential open pit development at the Speewah vanadium project in Western Australia. The study estimated mineral resources of 851 Mt at 0.32% V_2O_5. The company announced that further studies were required to examine the competitiveness of the proposed operation (NiPlats Australia Ltd., 2009).

Brazil.—Largo Resources Ltd. (Toronto, Ontario, Canada) announced that it may have gained access to one of the world's largest known vanadium deposits outside of China, after it signed a 20-year lease agreement with Brazil's Companhia Baiana de Pesquisa Mineral. The property is located in the municipality of Campo Alegre de Lourdes, State of Bahia. Under the terms of the deal, Largo was expected to take a 100% stake in the property following an initial payment of approximately $250,000, payable in 5 installments during 16 months (Metal-Pages, 2009b).

Canada.—Apella Resources Inc. (Vancouver, British Columbia) commenced the next phase of exploration on its 100% owned Iron-T iron-vanadium-titanium project, which was expected to include a 10-hole diamond drilling program and detailed mapping of the Bell River Complex, near Matagami, Quebec (Apella Resources Inc., 2009).

China.—China's V_2O_5 exports decreased 71.5% to 4,296 t, while exports of FeV decreased 57.3 % to 2,503 t from that of 2008 owing to weak demand from steelmakers (Metal-Pages, 2010). The largest producing region in China is the Panzhihua area of Sichuan Province, where China's Panzhihua New Steel and Vanadium Co., Ltd. (a subsidiary of Panzhihua Iron and Steel Group) is the main operation. In 2008, an expansion increased the operations FeV production capacity to 9,000 t/yr and V_2O_5 production capacity to 18,000 t/yr, making it the world's largest-capacity vanadium operation (Metal-Pages, 2008).

The second leading vanadium producer in China is the Chengde Xinxin Vanadium & Titanium Co., Ltd., which is ociated with the steel and vanadiferous slag production at engde Iron and Steel Group Co., Ltd. in Hebei Province. engde also made significant expansions in processing acity between 2003 and 2008 and became a significant plier to the world market. In September, the China Securities gulatory Commission approved the merger of Tangshan Iron Steel Co. with Handan Iron & Steel Ltd. and Chengde Xinxin nadium, paving the way for Hebei Iron and Steel Group Co. l., their parent company, to become China's second largest elmaker (Zhang, 2009).

India.—The Indian Ferro Alloy Producers Association urged Indian Finance Ministry to reconsider the 7.5% import tax V_2O_5. They have asked that the tax be reduced to 2%, which uld then be similar to the tax rate on raw materials such as rome and manganese ore (Metal-Pages, 2009a).

Japan.—Japan's FeV output in the first quarter of 2009 creased 71% to 305 t compared with 1,067 t in the same arter of 2008, reflecting the sharp drop in demand from ecialty steel, especially steels used in construction and chine tools. Producers cut production in the fourth quarter 2008 because of the global economic downturn. Japanese oduction increased moderately in April (197 t) and May (129 but was still low compared with the 2008 monthly average 290 t (Ryan's Notes, 2009a). Japan was expected to raise its ndard for the amount of vanadium added to its rebar steel, hich would increase its vanadium consumption in 2010.

Madagascar.—Uranium Star Corp. (Toronto, Ontario, anada) announced that it signed an agreement with adagascar Minerals and Resources (MMR) to purchase e remaining 25% of the Green Giant vanadium project southwestern Madagascar from MMR for the sum of 100,000. Once the sale is completed, Uranium Star will have 0% ownership of the 194-square-kilometer (76-square-ile) property (Uranium Star Corp., 2009). Uranium Star nounced plans to spend $10 million to conduct environmental, eotechnical, and metallurgical studies, as well as complete feasibility study on its Green Giant vanadium project. The reen Giant deposit is a continuous 18-kilometer (11-mile) ineralized trend of vanadium spanning the length of the roperty. Uranium Star recently built a licensed airstrip on the roperty making it accessible year-round using private aircraft Resource World, 2009).

Russia.—Russia is the third leading producer of vanadium orldwide and has extraction, mining, smelting, and ownstream master alloy production in addition to significant sers of vanadium metal. Nizhny Tagil Iron and Steel Works a subsidiary of Evraz Group S.A. (Moscow)], completed the cquisition of OAO Vanady-Tula, the leading Russian FeV roducer. Vanady-Tula accounted for 70% of Russia's 2009 anadium production (SteelOrbis, 2009).

South Africa.—South African steel producer Highveld Steel nd Vanadium Corp. Ltd. (Witbank), in which Russia's Evraz roup has a controlling stake, announced in April that Umnotho veSizwe Investment Holdings Ltd. (Johannesburg) would take a 26% interest in the Mapochs Mine, in Mpumalanga, under he country's Black Economic Empowerment program. The Mapochs Mine produces lumpy titaniferous magnetite ore, which is supplied exclusively to Vanchem Vanadium Products Pty. Ltd. (Witbank) operations to produce a variety of vanadium products. Vanchem, an independently managed division of Highveld, was expected to be transferred into Mapochs Newco (a subsidiary of Highveld). Also under the terms of the deal, a 23% equity stake in Mapochs Newco was expected to be sold to Lashka 81 Ltd., which was to change its name to Umnotho Iron and Vanadium Ltd., a subsidiary of Umnotho weSizwe (Creamer, 2009).

Outlook

Vanadium consumption is heavily influenced by steel production, high strength steel grades in particular. High strength steels are growing in use as the construction, energy, and transportation industries seek to maximize the strength and minimize the weight of their products. There is growth potential in vanadium's other end use industries as well. Aerospace applications are rapidly expanding, and vanadium consumption has been increasing with the introduction of the next generation commercial aircraft. The quest for fuel efficiency is key in the aerospace industry but also extends to automobiles, high-speed drilling, powerplants, and rail cars.

There are several different battery technologies in the process development and early commercialization stages. One technology showing promise in stabilizing energy distribution in renewable systems is the vanadium redox battery (VRB), which consists of an assembly of power cells in which two vanadium-based electrolytes are separated by a proton exchange membrane. The main advantages of the VRB are that it can offer almost unlimited capacity simply by using sequentially larger storage tanks, it can be left completely discharged for long periods of time with no ill effects, it can be recharged by replacing the electrolyte if no power source is available to charge it, and the battery suffers no permanent damage if the electrolytes are accidentally mixed (Johnstone, 2008). The VRB has also been shown to have the least ecological impact of all energy storage technologies.

There were no major new production facilities completed in 2009. Cancellation of Windimurra Mine redevelopment was the most prominent example of the impact of the economic downturn in the vanadium industry. Steel output declined by approximately 8% in 2009, causing vanadium consumption to decline sharply as well. However, the World Steel Association has predicted that steel production will increase by 8% in 2010 and approximately 6% in 2011. Given the strong outlook for global steel production, vanadium demand was expected to increase in 2010.

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TABLE 1
SALIENT VANADIUM STATISTICS[1]

(Metric tons of contained vanadium, unless otherwise specified)

	2005	2006	2007	2008	2009
United States:					
Production, ore and concentrate:					
Recoverable vanadium	--	--	--	W [r]	W
Recoverable vanadium[2]: value thousand dollars	--	--	--	W	W
Consumption, reported	3,910	4,030	4,970	5,170 [r]	5,000
Exports:					
Ferrovanadium	500 [r]	389	154	281	672
Vanadium pentoxide (anhydride)	247 [r]	341	327	249	401
Other oxides and hydroxides of vanadium	821 [r]	832	626	1,040	506
Imports for consumption:					
Ferrovanadium	712 [r]	685 [r]	1,440 [r]	2,720 [r]	353
Ash and residues[3]	1,070 [r]	637 [r]	1,000 [r]	1,040 [r]	791
Vanadium pentoxide (anhydride)	1,370	1,920	2,390	3,700	1,120
Other oxides and hydroxides of vanadium	186	129	42	144	25
Stocks:					
Ferrovanadium	343	275	253	234	232
Oxide	2	6	22	24	24
Other[4]	26	49	48	76	58
World, production from ore, concentrate, slag[5]	56,400	57,900	58,500	56,400 [r]	54,100

[r] Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mill, plus vanadium recovered from ferrophosphorous slag derived from domestic phosphate rock.

[3] Ash and residues from the manufacture of iron and steel.

[4] Consists principally of vanadium-aluminum alloy, small quantities of other vanadium alloys, vanadium metal, and ammonium metavanadate.

[5] Excludes U.S. production.

TABLE 2
U.S. CONSUMPTION OF VANADIUM, BY END USE AND FORM[1]

(Kilograms of contained vanadium)

	2008	2009
End use:		
Steel:		
Carbon	1,010,000 [r]	832,000
Full alloy	2,030,000 [r]	1,920,000
High-strength low-alloy	W [r]	W
Stainless and heat resisting	116,000	119,000
Tool	152,000 [r]	418,000
Total	3,310,000 [r]	3,290,000
Cast irons	W	W
Superalloys	39,000 [r]	12,800
Alloys (excluding steels and superalloys):		
Welding and alloy hard-facing rods and materials	W	W
Other alloys[2]	W	W
Chemical and ceramic uses:		
Catalysts	W	W
Pigments	W	W
Miscellaneous and unspecified	1,830,000 [r]	1,700,000
Grand total	5,170,000 [r]	5,000,000
Form:		
Ferrovanadium	4,190,000 [r]	3,910,000
Oxide	92,500 [r]	358,000
Other[3]	893,000 [r]	732,000
Total	5,170,000 [r]	5,000,000

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes magnetic alloys.

[3] Consists principally of vanadium-aluminum alloy, small quantities of other vanadium alloys, vanadium metal, and ammonium metavanadate.

TABLE 3
U.S. IMPORTS AND EXPORTS OF ALUMINUM-VANADIUM MASTER ALLOY AND VANADIUM METAL, INCLUDING WASTE AND SCRAP[1]

	Aluminum-vanadium master alloy		Vanadium metal, including waste and scrap	
	Quantity, gross weight (kilograms)	Value	Quantity, gross weight (kilograms)	Value
Imports for consumption:				
2008	618,000	$2,760,000	4,600	$409,000
2009:				
Belgium	34,600	158,000	3	6,890
Canada	--	--	312	110,000
China	--	--	38	18,400
Germany	--	--	21,300	805,000
Mexico	194,000	592,000	--	--
Netherlands	53,400	230,000	--	--
Total	282,000	979,000	21,700	940,000
Exports:				
2008	21,900,000	76,200,000	57,100	3,740,000
2009:				
Belgium	16,300	475,000	--	--
Brazil	3,790	77,800	--	--
Canada	1,800,000	4,940,000	--	--
China	6,190	64,300	--	--
Egypt	2,170	28,200	--	--
France	1,270	16,500	10	8,420
Germany	2,030	29,400	--	--
Guyana	8,180	50,200	--	--
India	649	1,580	--	--
Ireland	5,170	50,300	--	--
Israel	2,540	37,400	--	--
Japan	13,500	382,000	20,900	919,000
Kuwait	--	--	764	30,000
Malaysia	273	1,580	--	--
Mexico	9,190,000	20,200,000	--	--
Philippines	292	1,580	--	--
Russia	--	--	1,060	81,900
Saudi Arabia	350	9,550	--	--
Singapore	735	17,000	--	--
South Africa	194	1,580	--	--
Spain	291	20,500	--	--
United Kingdom	111,000	1,310,000	--	--
Total	11,200,000	27,800,000	22,700	1,040,000

-- Zero

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 4

U.S. IMPORTS AND EXPORTS OF FERROVANADIUM, VANADIUM PENTOXIDE (ANHYDRIDE), AND OTHER OXIDES AND HYDROXIDES OF VANADIUM[1]

	Ferrovanadium		Vanadium pentoxide (anhydride)[2]		Other oxides and hydroxides of vanadium	
	Quantity, V content (kilograms)	Value	Quantity, V content (kilograms)	Value	Quantity, V content (kilograms)	Value
Imports for consumption:						
2008	2,720,000 r	$158,000,000	3,700,000	$115,000,000	144,000	$4,320,000
2009:						
Australia	--	--	--	--	8,390	231,000
Austria	48,800	1,160,000	8,380	148,000	16,800	320,000
Brazil	535	48,700	--	--	--	--
Canada	197,000	7,390,000	--	--	--	--
China	--	--	174,000	3,130,000	--	--
Germany	2,020	133,000	126	9,840	--	--
India	2,620	106,000	--	--	--	--
Kazakhstan	395	14,200	--	--	--	--
Korea, Republic of	101,000	3,780,000	--	--	--	--
Russia	--	--	322,000	4,000,000	--	--
South Africa	--	--	581,000	8,540,000	--	--
Sweden	196	7,020	--	--	--	--
Taiwan	--	--	33,700	668,000	--	--
United Kingdom	--	--	2,500	38,500	--	--
Total	353,000	12,600,000	1,120,000	16,500,000	25,200	551,000
Exports:						
2008	281,000	12,600,000	249,000	5,650,000	1,040,000	11,300,000
2009:						
Argentina	66,400	713,000	3,100	58,500	1,200	8,380
Austria	--	--	3,270	45,400	--	--
Brazil	23,700	580,000	61,600	774,000	14,300	127,000
Canada	139,000	3,670,000	--	--	144,000	1,310,000
China	87,100	1,650,000	37,100	330,000	12,000	107,000
France	30,700	594,000	17,900	277,000	--	--
Germany	--	--	11,200	191,000	12,100	167,000
India	54,400	1,440,000	--	--	19,000	290,000
Italy	--	--	14,400	337,000	--	--
Japan	81	4,820	16,000	243,000	11,800	122,000
Korea, Republic of	86,900	2,000,000	19,200	165,000	18,300	214,000
Mexico	53,500	1,420,000	3,100	57,300	--	--
Netherlands	121,000	2,570,000	82,800	1,310,000	273,000	2,920,000
Saudi Arabia	--	--	10,800	184,000	--	--
Singapore	--	--	--	--	362	3,230
South Africa	--	--	76,800	324,000	--	--
Spain	--	--	25,500	292,000	--	--
Trinidad and Tobago	--	--	13,900	242,000	--	--
United Kingdom	--	--	36	4,430	--	--
Venezuela	8,610	307,000	4,010	136,000	--	--
Total	672,000	15,000,000	401,000	4,970,000	506,000	5,270,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] May include catalysts that contain vanadium pentoxide.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF VANADIUM-BEARING ASH AND RESIDUES[1]

Material and country	2008 Quantity, V_2O_5[2] content (kilograms)	2008 Value	2009 Quantity, V_2O_5[2] content (kilograms)	2009 Value
Ash and residues:[3]				
Canada	13,200	$4,700	2,250	$4,850
Mexico	1,030,000	18,000,000	788,000	12,300,000
United Kingdom	--	--	120	2,210
Total	1,040,000	18,000,000	791,000	12,300,000

-- Zero

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] V_2O_5 Vanadium pentoxide.

[3] Ash and residues from the manufacture of iron and steel.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS VANADIUM CHEMICALS[1, 2]

Material and country	2008 Quantity, V[3] content (kilograms)	2008 Value	2009 Quantity, V[3] content (kilograms)	2009 Value
Sulfates:				
China	2,010	$88,800	16,500	$182,000
India	150	30,500	--	--
Total	2,160	119,000	16,500	182,000
Vanadates:				
China	3,280	97,700	167	3,250
Germany	659	37,700	12,500	473,000
India	99	13,800	137	12,100
Japan	395	43,400	--	--
South Africa	160,000	3,800,000	182,000	2,550,000
United Kingdom	23,000	240,000	19,800	352,000
Total	187,000	4,230,000	214,000	3,390,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Comprises vanadium ore and miscellaneous vanadium chemicals.

[3] Vanadium.

Source: U.S. Census Bureau.

TABLE 7

VANADIUM: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, vanadium content)

Country	2005	2006	2007	2008	2009
Production from ores, concentrates, slag:[3]					
Australia	100	--	--	--	-
China[4]	17,000	17,500	19,000	20,000	21,000
Kazakhstan	1,000	1,000	1,000	1,000	1,000
Russia	15,100	15,100	14,500	14,500	14,500
South Africa	22,604 [5]	23,780 [5]	23,486 [5]	20,295 [r, 5]	17,000
Total	55,800	57,400	58,000	55,800 [r]	53,500
Japan, petroleum residues, ash, and spent catalysts[6]	560	560	560	560	560
Grand total	56,400	57,900	58,500	56,400 [r]	54,100

[r] Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] In addition to the countries listed, vanadium is also recovered from petroleum residues in Germany and several other European countries, but available information is insufficient to make reliable estimates. Table includes data available through May 27, 2010.

[3] Production in this section is credited to the country that was the origin of the vanadiferous raw material.

[4] Estimated 40% of vanadium recovered from vanadiferous slag.

[5] Reported figure.

[6] Production in this section is credited to the country where the vanadiferous product is extracted; available information is inadequate to permit crediting this output back to the country of origin of the vanadiferous raw material.

VERMICULITE

By Robert D. Crangle, Jr.

Domestic survey data and tables were prepared by Raymond I. Eldridge III, statistical assistant, and the world production le was prepared by Lisa D. Miller, international data coordinator.

Production of vermiculite concentrate in the United States is an estimated 100,000 metric tons (t) in 2009. Worldwide rmiculite production was approximately 505,000 t in 2009, light decrease from that of 2008. U.S. exports in 2009 were imated to be approximately 3,000 t, a decrease of 40% from se of 2008. U.S. imports of vermiculite were an estimated ,000 t, 47% less than those of 2008. The average unit value U.S. exfoliated vermiculite sold or used by producers was imated to be $487 per metric ton, about the same as that of 08.

oduction

Flakes of processed raw vermiculite concentrate are mica-like appearance and contain water molecules within their internal ucture. When the flakes are heated rapidly at a temperature 900° C or higher, the water flashes into steam, and the flakes pand into accordion-like particles. This expansion process called exfoliation, and the resulting lightweight material is emically inert, fire resistant, and odorless.

Two U.S. producers of vermiculite concentrate, Virginia rmiculite LLC with two operations (near Woodruff, SC, and Louisa County, VA) and W.R. Grace & Co. from its operation Enoree, SC, produced an estimated 100,000 t of vermiculite 2009. Domestic production (sold or used) data for vermiculite ere collected by the U.S. Geological Survey (USGS) from o voluntary canvasses—one for mine-mill (concentrator) erations and the other for exfoliation plants. Production data r nonrespondents were estimated based on production data ports from prior years. Data are rounded to one significant ure to avoid disclosing proprietary company information.

Vermiculite concentrate was shipped to exfoliating plants r conversion into lightweight material. Output of exfoliated rmiculite sold or used in 2009, using reported and estimated ta, was about 69,000 t, produced from both domestic d imported vermiculite concentrate (table 1). Exfoliated rmiculite was produced by 13 companies operating 17 plants 11 States (table 2). Of the 17 exfoliation plants, 8 responded the annual canvass, representing 47% of the estimated sold used exfoliated vermiculite tonnages listed in tables 1 and Data for the remaining operations were estimated from evious years' reported production levels. States that produced foliated vermiculite were, in descending order of estimated tput sold or used, South Carolina, Pennsylvania, New Jersey, rizona, Florida, Massachusetts, Illinois, New Mexico, Ohio, d Arkansas.

onsumption

Vermiculite has a wide range of uses that take advantage of s various attributes of fire resistance, reliable insulation, high liquid absorption capacity, inertness, and low density (table 3). Vermiculite is used in general building plasters, either in its own formulations or combined with other lightweight aggregates such as perlite. Special plasters include fire protection and acoustic products in which vermiculite is combined with a binder, such as gypsum or portland cement, fillers, and specialized additives (Roskill Information Services Ltd., 2004, p. 103).

Exfoliated vermiculite, sometimes treated with a water repellent, is used to fill pores and cavities in masonry construction and hollow blockwork to enhance acoustic, fire rating, and insulation performance. Finer grades of exfoliated vermiculite, combined with potassium or sodium silicate, are used to produce insulation shapes. The ability of vermiculite-base insulation shapes to resist attack by molten aluminum makes them especially useful as secondary insulation in the aluminum production process (Roskill Information Services Ltd., 2004, p. 112).

In horticulture, exfoliated vermiculite improves soil aeration and moisture retention. When vermiculite is mixed with peat or other composted materials, such as pine bark, the resulting product provides a good growing medium for plants. As a soil conditioner, exfoliated vermiculite can improve the aeration of "sticky" soils (containing clay) and the water retention characteristics of sandy soils. This allows for easier watering and reduces the likelihood of compaction, cracking, and crusting of the soil. Vermiculite is used in the fertilizer/pesticide market because of its ability to act as a carrier, bulking agent, and extender (Roskill Information Services Ltd., 2004, p. 108–109).

Other uses include refractory-insulation gunning and castable mixes and vermiculite dispersions. Finer grades of exfoliated vermiculite are used to partially replace asbestos in brake linings, primarily for the automotive market (Roskill Information Services Ltd., 2004, p. 112–113).

Prices

Published prices for vermiculite serve only as a general guide because of variations in application, quantity, source, and other factors. U.S. domestic prices for vermiculite concentrate, ex-plant, ranged from $95 to $400 per metric ton, largely dependent on grade sizing. The average value of imports into the United States, f.o.b. (free on board) barge Gulf Coast port, ranged from $210 to $460 per ton (Moeller, 2010). Courser grained vermiculite with greater thermal expansion commands a higher price, but no deposits within the United States yield this type of vermiculite, so a stable import market persists for this product.

The average unit value of U.S. exfoliated vermiculite sold or used by producers, using actual and estimated data, was about $487 per ton; this was a composite value that included exfoliated vermiculite produced from both U.S. and imported concentrate (table 1).

Foreign Trade

Trade data for vermiculite concentrate are not collected as a separate category by the U.S. Census Bureau but are included within the basket category "vermiculite, perlite, and chlorite, unexpanded" under Harmonized Tariff Schedule of the United States code 2530.10.0000. Total U.S. imports of vermiculite in 2009 (excluding any material from Canada and Mexico) were estimated to be about 39,000 t.

World Review

The Palabora Mining Co. (a member of Rio Tinto plc) manages the largest known vermiculite reserves in the world in South Africa. Approximately 94% of Palabora's mined vermiculite is exported, which accounts for an estimated 38% of the world's average annual total vermiculite production of about 200,000 t (Palabora Mining Co., 2010).

Imerys (Paris, France) was the world's second-ranked supplier of vermiculite in 2008, with production from deposits in Alice Springs, Northern Territory, Australia; Korla, China; and Shawa, Zimbabwe (Imerys, 2010, p. 9, 26).

Outlook

As a result of nearly 300 deaths attributed to asbestos-related diseases in the vicinity of Libby, MT, research regarding vermiculite contaminated with amphibole continues in this area, the locality of what was once the largest vermiculite mine in the world (Whitehouse and others, 2008; Hart and others, 2009). Studies on the Libby vermiculite mine, which closed in 1990, will likely continue for the foreseeable future.

Owing to the energy-intensive process associated with the exfoliation of vermiculite, natural gas prices, which remained stable in 2009, typically dictate price fluctuations for exfoliated vermiculite. In the event of an increase in natural gas prices, the cost for exfoliated vermiculite would probably likewise increase.

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TABLE 1
SALIENT VERMICULITE STATISTICS[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

		2005	2006	2007	2008	2009
United States:						
Production, concentrate[e, 2]		100	100 [3]	100 [3]	100 [3]	100 [3]
Exfoliated:[e]						
Quantity		85	90	85	82	69
Value[e]		35,100	36,500	36,500	40,100	33,600
Average value[e, 4]	dollars per metric ton	410 [5]	406	429	489	487
Exports[e]		5	5	5	5	3
Imports for consumption[6]		91	65 [e]	51	73	39
World, production		521	513	502 [r]	517 [r]	500 [e]

[e]Estimated. [r]Revised.

[1] Data are rounded to no more than three significant digits unless otherwise specified.

[2] Sold or used by producers.

[3] Rounded to one significant digit.

[4] Based on rounded data.

[5] Rounded to two significant digits.

[6] Source: UBM Global Trade, a division of United Business Media Ltd., 2010.

TABLE 2
ACTIVE VERMICULITE EXFOLIATION PLANTS IN THE UNITED STATES IN 2009

Company	County	State
Isolatek International, Inc.	Sussex	New Jersey.
J.P. Austin Associates, Inc.	Beaver	Pennsylvania.
Palmetto Vermiculite Co., Inc.	Spartanburg	South Carolina.
P.V.P. Industries, Inc.	Trumbull	Ohio.
Schundler Co., The	Middlesex	New Jersey.
Southwest Vermiculite Co., Inc.	Bernalillo	New Mexico.
Sun Gro Horticulture Canada Ltd.	Jefferson	Arkansas.
Do.	LaSalle	Illinois.
Thermal Ceramics Inc.	Macoupin	Do.
Therm-O-Rock East, Inc.	Washington	Pennsylvania.
Therm-O-Rock West, Inc.	Maricopa	Arizona.
Verlite Co.	Hillsborough	Florida.
Vermiculite Industrial Corp.	Allegheny	Pennsylvania.
Whittemore Co., Inc.	Essex	Massachusetts.
W.R. Grace & Co.	Maricopa	Arizona.
Do.	Broward	Florida.
Do.	Laurens	South Carolina.

Do. Ditto.

TABLE 3
ESTIMATED EXFOLIATED VERMICULITE SOLD OR USED IN THE UNITED STATES, BY END USE[1]

(Metric tons)

	2008	2009
Aggregates[2]	29,500	24,300
Insulation[3]	5,850	5,860
Agricultural:		
Horticultural	21,500	14,900
Soil conditioning	W	W
Fertilizer carrier	W	W
Total	W	W
Other[4]	W	W
Grand total[5]	82,000	69,000

W Withheld to avoid disclosing company proprietary data; included in "Grand total."

[1] Data rounded to no more than three significant digits; may not add to totals shown.

[2] Includes concrete, plaster, and premixes (acoustic insulation, fireproofing, and texturizing uses).

[3] Includes loose-fill, block, and other (high-temperature and packing insulation and sealants).

[4] Includes various industrial and other uses not specified.

[5] Rounded to two significant digits because of estimated data.

TABLE 4
VERMICULITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2005	2006	2007	2008	2009[e]
Argentina	1,403	1,585	1,726	1,813 [r]	1,800
Australia[e]	12,000	13,000	13,000	13,000	12,000
Brazil, concentrate	24,191	19,279	18,952	20,089 [r]	20,100
China[e]	100,000	110,000	110,000	120,000	120,000
Egypt[e]	12,000	12,000	5,770 [r, 3]	7,560 [r, 3]	8,000
India[e]	4,500	4,600	4,700	4,800	4,900
Japan[e]	6,000	6,000	6,000	6,000	6,000
Russia[e]	25,000	25,000	25,000	25,000	25,000
South Africa	209,801	197,765	198,526	199,764	193,334 [3]
Uganda	2,574	3,512	3,500 [e]	3,500 [e]	3,600
United States, concentrate, sold and used by producers[e]	100,000	100,000 [4]	100,000 [4]	100,000 [4]	100,000 [4]
Zimbabwe	23,045	20,000	15,000	15,000 [e]	10,000
Total	521,000	513,000	502,000 [r]	517,000 [r]	500,000

[e] Estimated. [r] Revised.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes production by countries for which data are not available and for which general information is inadequate for formulation of reliable estimates. Table includes data available through July 13, 2010.

[3] Reported figure.

[4] Rounded to one significant digit.

WOLLASTONITE

By Robert L. Virta

Domestic survey data were prepared by Monica D. Zeigler, statistical assistant.

Wollastonite was mined by two companies in the United ates in 2009. U.S. production data collected by the U.S. eological Survey (USGS) are withheld to avoid revealing mpany proprietary data, but the U.S. production rate was ported in the trade literature to be about 65,000 metric tons per ar (t/yr). There was a decline in production and sales because poor market conditions worldwide. Exports of wollastonite ere estimated to be in the range of 22,000 to 25,000 metric ns (t), a decline from those of 2008. Imports of wollastonite ere estimated to be less than 4,000 t. World sales of refined ollastonite products were estimated to be in the range of 0,000 to 470,000 t in 2009 compared with 480,000 to 520,000 n 2008.

roduction

In 2009, domestic wollastonite production decreased from at of 2008. Data collected by the USGS are withheld to oid disclosing proprietary information, but U.S. wollastonite oduction rate was reported in the trade literature to be about 5,000 t/yr in 2009 (Ellen, 2009; Feytis, 2009; Industrial inerals, 2009b).

Wollastonite has been mined commercially in California and ew York. The California deposits, which are in Inyo, Kern, and iverside Counties, were mined between 1930 and 1970. These perations were limited in size, producing only a few thousand etric tons each year for ceramics, decorative stone, paint, and ineral wool production before closing.

Wollastonite deposits in New York have been mined for ore than 50 years. Two companies mined wollastonite in 009—NYCO Minerals, Inc. (NYCO) [a subsidiary of Resource apital Fund IV L.P. (RCF), Denver, CO], which operated a ine in Essex County, and R.T. Vanderbilt Co., Inc., through s Gouverneur Minerals Division, which operated a mine in ewis County. The NYCO deposit contains diopside, garnet, nd wollastonite. Parts of the deposit contain up to 60% ollastonite. The ore was processed at the Willsboro, NY, plant, here the garnet was removed by using high-intensity magnetic eparators. NYCO also chemically modified the surfaces of ome of its wollastonite products to improve their performance. .T. Vanderbilt's deposit consists primarily of wollastonite as ell as minor amounts of calcite and prehnite and trace amounts f diopside. The ore was processed at the company's St. awrence County plant, where it was milled and air classified. .T. Vanderbilt also produced surface-treated products.

NYCO, which operates a wollastonite mine and mill in ewis County, proposed a possible land swap with the State. he company would access 101 hectares of wollastonite eserves located in the Jay Mountain Wilderness, next to the urrent mine site. In return, NYCO would acquire and donate nvironmentally important land to New York's Forest Preserve system. The land swap would require a State constitutional amendment (Knight, 2009).

NYCO reported that sales declined about 40% in early 2009 compared with those of the same period in 2008. The slumping automotive industry was the primary reason for the decline although the decline in construction activity also affected sales. NYCO indicated that production at its Lewis Mine was about 45,000 t in 2009 (Feytis, 2009; Industrial Minerals, 2009b).

R.T. Vanderbilt Co., Inc. announced staff reductions at its Balmat mill in Fowler, NY. The global economic recession resulted in lower sales of wollastonite, prompting the company to reduce expenses through staff reductions. The mill in Fowler processes about 20,000 t/yr of wollastonite (Ellen, 2009).

Consumption

The USGS does not collect end-use data on wollastonite. However, based on company press releases, general overview articles, U.S. manufacturing trends, and consumption estimates published by Industrial Minerals (1999), plastics and rubber applications were estimated to account for 25% to 35% of U.S. sales in 2009, followed by ceramics with 20% to 25%; paint, 10% to 15%; metallurgical applications, 10% to 15%; friction products, 10% to 15%; and miscellaneous, 10% to 15%. Ceramic applications probably account for 30% to 40% of wollastonite sales worldwide, followed by polymers (plastics and rubber) with 30% to 35% of sales, and paint with 10% to 15% of sales (Kendall, 2001; Robinson, 2006). The remaining sales were for construction, friction products, and metallurgical applications.

The distribution of sales among markets was not thought to have changed significantly in 2009 from that of 2008 because nearly all of the markets served by wollastonite were affected by the global recession.

In ceramics, wollastonite decreases shrinkage and gas evolution during firing, increases green and fired strength, maintains brightness during firing, permits fast firing, and reduces crazing, cracking, and glaze defects. In metallurgical applications, wollastonite serves as a flux for welding, a source for calcium oxide, a slag conditioner, and to protect the surface of molten metal during the continuous casting of steel. As an additive in paint, it improves the durability of the paint film, acts as a pH buffer, improves its resistance to weathering, reduces gloss, reduces pigment consumption, and acts as a flatting and suspending agent. In plastics, wollastonite improves tensile and flexural strength, reduces resin consumption, and improves thermal and dimensional stability at elevated temperatures. Surface treatments are used to improve the adhesion between the wollastonite and the polymers to which it is added. As a substitute for asbestos in floor tiles, friction products, insulating board and panels, paint, plastics, and roofing products, wollastonite is resistant to chemical attack, inert, stable at high temperatures, and improves flexural and tensile strength (Roskill Information Services Ltd., 1996, p. 58–59, 78–81, 104–107, 119, 123–128).

Prices

Quoted prices for domestically produced acicular wollastonite, ex-works, were $200 per metric ton for 200-mesh, $191 per ton for 325-mesh, and $444 for high-aspect-ratio wollastonite. Prices for wollastonite from China, free on board, in bulk, were $80 to $90 per ton for 200-mesh and $90 to $100 per ton for 325-mesh (Industrial Minerals, 2009c). Hawley (2009) indicated that wollastonite sold for plastics applications was $661 to $1,984 per ton, and prices for ceramic grades of wollastonite were $220 to $496 per ton from a major U.S. producer. Quoted prices should be used only as a guideline because actual prices depend on the terms of the contract between the seller and the buyer.

Foreign Trade

Comprehensive trade data were not available for wollastonite. U.S. exports were estimated to be 30,000 to 40,000 t in 2008 (Hawley, 2009). Based on declines in sales resulting from the global economic recession, exports were likely in the range of 22,000 t to 25,000 t in 2009. Wollastonite was exported by ship to Australia, Brazil, Colombia, the Dominican Republic, Germany, Hong Kong, the Netherlands, the Republic of Korea, Singapore, and the United Kingdom (United Business Media Global Trade, undated). Additional amounts probably were transported by truck or train to Canada.

U.S. imports were estimated to be less than 4,000 t in 2009. Imports transported by ship were received from Canada, Finland, and India. Canada was reported to be the leading source of wollastonite imported into the United States by ship, followed by India and Finland (United Business Media Global Trade, undated). Shipments of wollastonite from Canada were transshipments or misidentified because no wollastonite production was reported there. Small additional amounts may have been shipped from Canada and Mexico by rail or truck.

World Review

World production of crude wollastonite ore probably declined 10% to 15% in 2009 because of the global recession. The decline in global production would have been greater, but the economies of China, India, and a few other Asian countries grew slightly. This enabled producers in China and India, which account for about 70% of the world wollastonite production, to experience only slight declines in production compared with production in 2008. Estimated crude ore production was in the range of 520,000 to 540,000 t in 2009 compared with 600,000 t in 2008. Sales of refined wollastonite products probably were in the range of 430,000 to 470,000 t in 2009 compared with 480,000 to 520,000 t in 2008.

In 2009, wollastonite production in China was estimated to be 290,000 to 300,000 t, and production in India was probably 105,000 to 110,000 t based on 2008 data published by Feytis (2009). The United States ranked third in wollastonite production (about 65,000 t). Production in Mexico was estimated to have declined slightly to 40,000 t in 2009 based on published data for 2008 (Feytis, 2009; Ministry of the Economy [Mexico], 2009, p. 137). Following Mexico in ranking were Finland (15,600 t in 2008), Spain (9,500 t in 2008), and Namibia (55 t in 2008) (Brown and others, 2010, p. 105). Small amounts of wollastonite may have been produced in other countries. Data for 2009 were not available for most countries.

Canada.—Canadian Wollastonite Co. continued work on development of its deposit in eastern Ontario, but plans to build a pilot plant, with a capacity of 15,000 t/yr of wollastonite and 10,000 t/yr of byproduct diopside, on the site were delayed owing to the decline in wollastonite markets. Ore was shipped to a flotation facility for further testing (Industrial Minerals, 2009a, d).

India.—Domestic demand for wollastonite continued to increase in India, although at a slower growth rate than in 2008. Wolkem India Ltd., the leading world producer of wollastonite, was able to sustain production despite the slowdown in demand in India and the decline in India's export markets (Feytis, 2009).

Spain.—Compania Mineral Illustracion (owned by Crimidesa Group) continued to increase its production and sales through 2008. Production was 20,000 t in 2008. The company was a relative newcomer to the wollastonite industry, beginning in 2003. The deposit was near Aldea del Obispo, Salamanca and contained an estimated 26 million metric tons of resources. With slightly higher iron content than wollastonite from some deposits, Compania Mineral sold wollastonite for ceramics and casting applications in Western Europe but was beginning to focus some of its sales on container glass, which was not a typical market for wollastonite (Feytis, 2009).

Outlook

Demand for and production of wollastonite declined in 2008 because the global recession resulted in a downturn in the industries that used wollastonite. The U.S. manufacturing industries remained at reduced operating levels, resulting in reduced demand for wollastonite for such applications as powder coatings for consumer appliances, surface conditioners for steel casting, ingredients for manufacturing technical ceramic bodies, and reinforcements for plastics products. Commercial and residential construction did not rebound in 2009, resulting in a continued low demand for wollastonite for architectural paints, caulks, ceramic tile glazes and bodies, roof coatings, sanitaryware, sealants, stucco, and wallboard. Use of wollastonite in structural clay products, such as brick and quarry tile, likely declined because of the continued slow construction markets. The automotive industry also did not recover significantly from the declines in 2008 and its reduced output affected sales of wollastonite for the manufacture of such items as friction products and wollastonite-reinforced plastic automotive components.

Industrial output and construction both appeared to be increasing slightly and hinted at the beginnings of an economic recovery in many of the world economies. Economic growth was expected to be greatest in countries with developing and emerging economies, averaging 6% in 2010 and about 8% in 2011. The economies of other countries were expected to ncrease at a slower pace, averaging 2% in 2010 and 2.5% in 2011 (Funk, 2010; International Monetary Fund, 2010). As a result, wollastonite production in the United States may increase slightly in 2010. Faster economic growth in Asian markets is ikely to result in increased production in China and India in 2010.

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ZEOLITES

By Robert L. Virta

Domestic survey data and table were prepared by Monica D. Ziegler, statistical assistant.

In 2009, natural zeolites were mined by 10 companies in the nited States, with one other company working from stockpiled aterials or zeolites purchased from other producers for resale. line production was 59,500 metric tons (t) in 2009 compared ith 60,100 t in 2008, and U.S. consumption was 59,400 t in 009 compared with 58,500 t in 2008. The major markets were animal feed, odor control, pet litter, water purification, in ecreasing order by tonnage. These four applications accounted or more than 75% of domestic consumption. Exports of natural eolites (other than gem quality) were estimated to be less than 00 t, and imports were estimated to be less than 200 t. World roduction was estimated to be in the range of 2.8 million to 3.3 million metric tons (Mt).

Commercial zeolite deposits in the United States are ssociated with the alteration of volcanic tuffs in alkaline lake eposits and open hydrologic systems. In the United States, hese deposits are in Arizona, California, Idaho, Nevada, New Mexico, Oregon, Texas, and Wyoming. Zeolites in these eposits are chabazite, clinoptilolite, erionite, mordenite, nd phillipsite. Other components, such as orthoclase and lagioclase feldspars, montmorillonite, opal, quartz, and olcanic glass, are present in some deposits.

Production

Domestic data for natural zeolites were collected by means of a voluntary survey of the domestic mining industry. Survey orms were sent to 11 companies, and 9 responded. Responses ccounted for more than 98% of the production and end-use data.

Conventional open pit mining techniques are used to mine natural zeolites. The overburden is removed to allow access to he ore. The ore may be blasted or stripped for processing by using front-end loaders or tractors equipped with ripper blades. n processing, the ore is crushed, dried, and milled. The milled ore may be air-classified based on particle size and shipped in bags or bulk. The crushed product may be screened to remove fine material when a granular product is required, and some pelletized products are produced from fine material. Producers also may modify the properties of the zeolite or blend their zeolite products with other materials before sale to enhance their performance.

Ten companies mined natural zeolites in the United States in 2009. One company did not mine zeolites during the year but sold from stocks or purchased zeolites from other producers for resale (table 1). Chabazite was mined in Arizona; clinoptilolite was mined in California, Idaho, Nevada, New Mexico, and Texas; and mordenite was mined in Nevada. Domestic production of zeolites was 59,500 t compared with 60,100 t of production in 2008. New Mexico was the leading producing State in 2009, followed by Idaho, Texas, Arizona, California, and Nevada.

During 2009, the U.S. zeolite industry was facing a major consolidation. ZEOX Corp., Vancouver, British Colombia, Canada, began discussions with Imagin Minerals, Inc., Wilton, CT, concerning a possible merger of the two companies (ZEOX Corp., 2009). Tentative plans were for ZEOX to purchase all shares of Imagin Minerals. Imagin Minerals was the leading producer of natural zeolites in North America, through its subsidiary St. Cloud Mining Co., with about 54% of the U.S. market (ZEOX Corp., 2010). In 2007, ZEOX Corp., Vancouver, British Columbia, Canada, acquired two natural zeolite producers, GSA Resources Inc. with a mine and mill in Arizona and Ash Meadows, LLC with a mine in California and mill in Nevada (Virta, 2010).

Bear River Zeolite Co. (a subsidiary of United States Antimony Corp.) reported that sales revenue decreased by 2% to $1.54 million in 2009 compared with those of 2008 and shipments decreased by 3% to 11,500 t compared with those of 2008 (United States Antimony Corp., 2010, p. 10).

Daleco Resources Corp., through its subsidiary Clean Age Minerals, Inc., had extracted about 1,300 t of clinoptilolite through September 2009 at its Marfa, TX, zeolite deposit. The company planned to use this material for product testing. Limited sales of their zeolite were made in 2009 for agricultural and wastewater treatment applications, but large-scale mining of the deposit had not commenced (Daleco Resources Corp., 2010, p. 9).

Consumption

About 59,400 t of natural zeolites was sold in 2009 in the United States compared with 58,500 t in 2008. Domestic uses for natural zeolites were, in decreasing order by tonnage, animal feed, odor control, pet litter, water purification, fungicide or pesticide carrier, wastewater cleanup, gas absorbent, horticultural applications (soil conditioners and growth media), oil absorbent, desiccant, and aquaculture. Animal feed, odor control, pet litter, and water purification applications accounted for more than 75% of the domestic sales tonnage. Increased sales of natural zeolites were reported for animal feed, desiccant, fertilizer, fungicide and pesticide carriers, gas absorbent, odor control, and wastewater treatment applications. Sales declined slightly for aquaculture, catalysts, oil absorbent, pet litter, and water purification applications.

Prices

Prices for natural zeolites vary with zeolite content and processing. Unit values, obtained through the U.S. Geological Survey canvass of domestic zeolite producers, ranged from $30 to $900 per metric ton. The bulk of the tonnage sold was between $100 and $200 per ton, which was typical of large, bulk shipments. Eyde and Holmes (2006, p. 1058) reported that prices for industrial or agricultural applications ranged from $30 to $70 per ton for granular products coarser than 40-mesh and from $50 to $120 per ton for finer (-40 to +325-mesh) ground material.

Producers also sell custom-processed zeolites and finished products that can cost up to about $8,000 per ton when the products are sold by the kilogram. For such products as pet litter, fish tank media, or odor control applications, prices ranged from $0.50 to $4.50 per kilogram. Eyde (2009) reported that the price for modified clinoptilolite and extruded and activated chabazite products sold for as much as $8 per kilogram. Quoted prices should be used only as a guideline because actual prices depend on the terms of the contract between seller and buyer.

Foreign Trade

Comprehensive trade data were not available for natural zeolites. In 2009, exports of natural zeolites (other than gem-quality specimens) were estimated to be less than 500 t and imports were estimated to be less than 200 t. The bulk of the U.S. zeolite trade was in synthetic zeolite products.

World Review

World production of natural zeolites was in the range of 2.8 to 3.3 Mt in 2009 based on reported production by some countries, world market trends, and production estimates published in trade journals.

Natural zeolite production data are not available for most countries. Countries mining large tonnages of zeolites typically use them in low-value applications. The ready availability of zeolite-rich rock at low cost and the shortage of competing minerals and rocks are probably the most important factors for its large-scale use. It is also likely that a significant percentage of the material sold as zeolites in some countries is ground or sawn volcanic tuff that contains only a small amount of zeolites. Some examples of such usage are dimension stone (as an altered volcanic tuff), lightweight aggregate, pozzolanic cement, and soil conditioners.

Pozzolans are finely ground siliceous or siliceous and aluminous materials that react with calcium hydroxide, in the presence of moisture, at ordinary temperatures to form compounds possessing cementitious properties (Bruce, 2005).

Estimates for individual countries were: China (including pozzolan applications), 1.75 to 2.25 Mt; Jordan (nearly all for pozzolan applications), 400,000 to 450,000 t; the Republic of Korea, 160,000 to 170,000 t; Japan (including pozzolan applications), 150,000 to 160,000 t; Turkey, 100,000 t (including pozzolan applications); Slovakia, 90,000 t; the United States, 59,500 t; Ukraine (including pozzolan applications), 20,000 to 40,000 t; Hungary, 20,000 to 30,000 t; Cuba, 25,000 t; New Zealand, 17,000 to 20,000 t; Bulgaria (excluding pozzolan applications), 15,000 t; South Africa, 10,000 to 15,000 t; Australia, Russia, and Spain, 5,000 to 10,000 t each; Canada, Greece, Italy, and the Philippines, 3,000 to 5,000 t each; Mexico, 1,000 t; and Indonesia (excluding pozzolan applications), 400 to 500 t. Small amounts of natural zeolites (probably less than 1,000 to 2,000 t) also were produced in Argentina, Armenia, Georgia, Germany (excluding pozzolan applications), Serbia, and Slovenia.

Outlook

Although U.S. production declined in 2009 from that of 2008, sales of natural zeolites increased slightly. Markets for natural zeolites generally were smaller and less associated with construction and manufacturing applications than most other industrial minerals. Consequently, the global economic recession had only a relatively minor impact on the industry. Although increases in consumption in any particular market were modest, declines in other markets also were small. Sales of natural zeolites may continue to increase at a rate of 2% to 3% per year for the near future as markets tied to the environment, farming, horticulture, and ranching continue to expand.

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TABLE 1
DOMESTIC ZEOLITE PRODUCERS IN 2009[1]

State and company	Type of zeolite
Arizona:	
GSA Resources, Inc. (ZEOX Corp.)	Chabazite.
UOP LLC	Chabazite/mordenite.
California:	
Ash Meadows, LLC (ZEOX Corp.)	Clinoptilolite.
KMI Zeolite Inc.	Do.
Idaho:	
Bear River Zeolite Co. (United States Antimony Corp.)	Do.
Steelhead Specialty Minerals, Inc.	Do.
Teague Mineral Products Co.	Do.
Nevada, Moltan Co., L.P.	Clinoptilolite/mordenite.
New Mexico, St. Cloud Mining, Inc.	Clinoptilolite.
Texas, Zeotech Corp.	Do.

Do. Ditto.

[1] Addwest Minerals International Ltd. worked from stocks or purchased zeolites from other producers for resale.

ZINC

By Amy C. Tolcin

Domestic survey data and tables were prepared by Pamela A. Wiser, statistical assistant, and the world production tables were prepared by Lisa D. Miller, international data coordinator.

In 2009, U.S. production of recoverable zinc was 710,000 metric tons (t), a 5% decrease from that of 2008 (table 1). The value of domestic mine production was approximately $1.22 billion. Alaska continued to be the dominant zinc-producing State, accounting for 93% of recoverable production. Zinc was also produced from mines in Idaho, Missouri, Montana, Tennessee, and Washington. Estimated refined zinc production in 2009 was 203,000 t. Apparent consumption of refined zinc was 893,000 t, 12% lower than that of 2008. Domestic exports of zinc contained in ores and concentrates increased by 8% to 785,000 t in 2009 and were predominantly sent to Canada (29%), the Republic of Korea (24%), Spain (15%), and Japan (10%) (table 7). Imports for consumption of zinc contained in ores and concentrates increased by 17% to 74,200 t from those in 2008. Total U.S. refined zinc production in 2009 was estimated to have decreased by 29% to 203,000 t. Imports of refined zinc in 2009 decreased by 5% to 686,000 t. Refined zinc was imported primarily from Canada (80%), Mexico (12%), and Peru (7%). Domestic exports of refined zinc decreased by 294 t to 2,960 t in 2009. Global zinc mine production decreased by 3% to 11.2 million metric tons (Mt), and zinc metal production decreased by 3% to 11.4 Mt (tables 10, 11).

Legislative and Government Programs

A U.S. Government stockpile of zinc has been maintained since 1967 for national defense purposes. In 1992, Public Law 102–484, which authorized the disposal of the entire inventory of zinc from the National Defense Stockpile (NDS), was signed. The Defense Logistics Agency (DLA), which maintains the NDS, was authorized to sell 27,200 t of zinc during fiscal year 2009 (October 1, 2008, to September 30, 2009; actual quantity sold would be limited to remaining inventory). However, there were no sales of zinc during the fiscal year; sales of zinc from the NDS were suspended in August 2008 owing to concerns regarding domestic availability and access to various raw materials.

In August 2006, the Department of Defense (DOD) submitted an initial report to Congress that recommended a more detailed review of the current stockpile disposal policy. In January 2008, a working group was established to review the findings of the previous studies and the issues raised by Congress. In April, the working group submitted a report to Congress proposing to reconfigure the NDS. The report supported the NDS' action to temporarily suspend or limit the sale of 13 mineral commodities in the NDS inventory, identified 39 other materials that should be monitored to ensure future availability, and concluded that 11 materials used in the largest quantities by the DOD should be considered for strategic sourcing, including zinc (U.S. Department of Defense, 2009, p. 8, 58).

Production

Mine.—In 2009, zinc was produced in six States, with Alaska the leading zinc-producing State. Other zinc-producing States were Idaho, Missouri, Montana, Tennessee, and Washington. Domestic mine production of recoverable zinc in 2009 was 710,000 t, a 5% decrease from that of 2008. An increase in production in Alaska was offset by decreases in production in Montana, New York, Tennessee, and Washington owing to the closure of zinc-producing mines in these States. Domestic mine production data were collected by the U.S. Geological Survey (USGS) from a voluntary survey of lode-mine production from seven operations. Six responded representing 99% of the data in tables 1 and 2.

Alaska.—Teck Resources Ltd. (Teck; Vancouver, British Columbia, Canada) operated the open pit Red Dog zinc-lead mine in the Northwest Arctic Borough, Alaska, under a royalty agreement with NANA Regional Corp., an Alaskan Native-owned corporation. Since the third quarter of 2007, Teck has paid NANA a percentage of the net proceeds of the production from the mine, starting at 25% and increasing to 50% by successive increments of 5% every 5 years.

Zinc in concentrate production at Red Dog increased by 13% in 2009 from that of 2008 to a production record of 583,000 t owing to increased mill operating rates and several site-improvement initiatives that were implemented during the year. In 2009, approximately 30% of Red Dog's zinc concentrates were refined at Teck's metallurgical complex at Trail, British Columbia, Canada. Remaining concentrates were sent to Asia and Europe. Reported ore reserves at yearend 2009 totaled 57.6 Mt averaging 16.2% zinc. Zinc in concentrate production in 2010 was projected to decline to 550,000 t (Teck Resources Ltd., 2010a, p. 41, 44; 2010b, p. 27).

Teck continued to work towards receiving the required permits for the Aqqaluk Deposit, the next ore body to be developed at Red Dog. Teck's operating plan was to continue mining the Main Pit until mid-2011, at which time, the ore would be supplemented with ore from Aqqaluk to maintain efficient production rates. Permitting delays for Aqqaluk owing to various appeals and petitions may negatively affect future production at Red Dog. Red Dog was in compliance with the total dissolved solids limits according to the settlement filed in 2008 by the Village of Kivalina (Teck Resources Ltd., 2010b, p. 17).

Hecla Mining Co.'s (Coeur d'Alene, ID) underground Greens Creek Mine is in a polymetallic (silver-zinc-gold-lead) massive sulfide deposit located on Admiralty Island in the Tongass National Forest near Juneau. Products included gold and silver dore, as well as lead and zinc concentrates, which were exported to foreign smelters. In 2009, zinc in concentrate production totaled 63,800 t. Reserves at yearend were 7.34 Mt of ore grading an average of 10.3% zinc (Hecla Mining Co., 2010b, p. 12).

Historically, Greens Creek was completely powered by onsite diesel generators. In 2006, necessary infrastructure was completed to allow surplus hydroelectric power supplied by Alaska Electric Light and Power Co. (AEL&P) to reach Greens Creek's facilities. During 2009, the mine received an increased proportion of its power needs from hydroelectricity, and the company expected most, if not all, of its power to be supplied from AEL&P in 2010. The project was expected to reduce Greens Creek's production costs, which had increased significantly owing to high diesel fuel prices during the past few years (Hecla Mining Co., 2010b, p. 12).

Idaho.—Hecla Mining operated the Lucky Friday Mine, an underground silver-lead-zinc mine in the Coeur d'Alene Mining District in northern Idaho. Products included silver-lead concentrates and zinc concentrates. All concentrates in 2009 were sent to Teck's facility at Trail for processing. Zinc in concentrate production at Lucky Friday increased in 2009 to 9,360 t from 8,510 t in 2008. At yearend, reserves measured 1.2 Mt of ore grading an average of 2.6% zinc (Hecla Mining Co., 2010a, p. 8; 2010b, p. 21).

During 2009, Hecla resumed the early stage development of an internal shaft that would provide access to ore reserves deeper than the current mining level and potentially extend Lucky Friday's mine life. The project had been placed on hold in 2008 owing to lower metals prices (Hecla Mining Co., 2010b, p. 15).

Missouri.—Doe Run Resources Corp. (St. Louis, MO) operated a series of production shafts that run along the Viburnum Trend lead-zinc-copper ore body in southeast Missouri. Doe Run processed the ore at four mills to produce primarily lead concentrates and to a lesser extent, zinc and copper concentrates.

Tennessee.—In May, Nyrstar NV (Balen, Belgium) acquired the Mid-Tennessee zinc mine complex from Strategic Resource Acquisition Corp. (Toronto, Ontario, Canada) for approximately $12 million, and in December, Nyrstar acquired the East Tennessee zinc mine complex from Glencore International AG (Baar, Switzerland) for approximately $116 million. The acquisitions were part of Nyrstar's strategy to begin pursuing mining opportunities that favor resources that support its existing smelting business markets (mainly, copper, gold, lead, silver, and zinc). The Mid-Tennessee mine complex had been on care-and-maintenance status since October 2008 because zinc prices declined during 2008. The East Tennessee complex had been on care-and-maintenance status since February 2009. Nyrstar planned to reopen and operate the six mines under the name Nyrstar Tennessee Mines. The combined production capacity for the mines was 130,000 metric tons per year (t/yr) of zinc in concentrate. The concentrates would provide 100% of the feedstock needs at Nysrtar's Clarksville, TN, zinc refinery. Mine life for the complex was projected to be 15 years (Nyrstar NV, 2010a, p. 26, 55, 80–81).

Washington.—Teck temporarily shut down the Pend Oreille zinc-lead mine in February as a result of reduced zinc metal demand and low zinc prices. The mine produced 4,800 t of zinc in concentrate during 2009 before operations were suspended. All concentrates were trucked to Teck's operations at Trail, 80 kilometers (km) northwest of the mine. Teck acquired ownership of Pend Oreille in 1996 and reopened the mine for commercial production in 2004. Yearend reserves at Pend Oreille were 1.9 Mt of ore grading 6.1% zinc (Teck Resources Ltd., 2010a, p. 45; 2010b, p. 27).

Smelter.—Domestic zinc metal production data were estimated based on publicly available information. In 2009, refined zinc was produced mainly in two States—Pennsylvania (Horsehead Holding Corp.'s Monaca facility) and Tennessee (Nyrstar's Clarksville facility). Estimated refined zinc production in 2009 was 203,000 t.

Primary.—Nyrstar's Clarksville electrolytic zinc refinery was the only primary zinc smelter in the United States. Products included Special High Grade (SHG) zinc metal and galvanizing alloys as well as a number of byproducts, including cadmium metal, intermediate copper cementate, leach residues, sulfuric acid, and synthetic gypsum. Refined zinc production in 2009 decreased by 25% from that of 2008 to 94,000 t owing to reduced production levels the company voluntarily took during the first half of the year in response to the downturn in the zinc market. The refinery returned to full production in July once market conditions improved. Nyrstar scheduled a roaster shutdown for the second half of 2010, which would potentially reduce 2010 production by 10,000 t from its capacity of 125,000 t (Nyrstar NV, 2010a, p. 26; 2010b, p. 4).

Secondary.—Horsehead (Monaca, PA) produced zinc metal—primarily Prime Western Grade (PW) and to a lesser extent, Special Special High Grade (SSHG)—and zinc oxide at its electrothermic zinc smelter (159,000 t/yr capacity) in Monaca. The PW zinc was sold to hot-dip galvanizers and brass manufacturers, and the SSHG zinc was used as feed for the production of high-purity zinc alloys and powder. Feedstock for metal and oxide production was composed entirely of secondary materials; 65% was sourced from Horsehead's electric arc furnace (EAF) dust recycling operations, and the balance was composed of dross and skimmings sourced from hot-dip galvanizers and other zinc-bearing residues sourced from the zinc, brass, and alloying industries. In 2009, Horsehead entered into a long-term contract to source EAF dust from a leading U.S. steel minimill and acquired the EAF dust collection business of Envirosafe Services of Ohio, Inc., a landfill disposer of EAF dust (Horsehead Holding Corp., 2010, p. 3, 6–9).

In addition to the Monaca facility, Horsehead operated five other facilities, including four EAF dust recycling operations located in Beaumont, TX; Calumet, IL; Palmerton, PA; and Rockwood, TN; and a hydrometallurgical metals recovery facility in Bartlesville, OK. Total EAF dust processing capacity was 561,000 t/yr. The company planned to further increase its EAF dust recycling capacity by constructing a fifth facility in Barnwell, SC. The new facility would have the capacity to recycle 163,000 t/yr of EAF dust. The first kiln was expected to start running in the second quarter of 2010 (Horsehead Holding Corp., 2010, p. 3, 6–9).

Horsehead operated its recycling facilities at reduced rates for most of the year. In 2009, Horsehead recycled 373,000 t of EAF dust compared with 470,000 t in 2008. The company attributed the processing rate reduction to a decline in domestic steel production and a weaker economy. At the end of the year, however, all facilities returned to operating at full capacity (Horsehead Holding Corp., 2010, p. 3, 6–9).

Secondary refined zinc was also produced to a lesser extent at U.S. Zinc's (owned by Votarantim Metais, São Paulo, Brazil) operations in Coldwater, MI, and Houston, TX. The facilities produced PW grade and continuous galvanizing grade zinc metal primarily from galvanizing residues, such as dross and skimmings.

Consumption

Apparent consumption of refined zinc in 2009 was 893,000 t, 12% lower than that of 2008. Of the total zinc consumed, about 55% was estimated to be used in galvanizing, 21% in zinc-based alloys, 16% in brass and bronze, and 8% in other uses. Zinc compounds and dust were used principally by the agriculture, chemical, paint, and rubber industries. Infrastructure improvement projects (funded by the American Recovery and Reinvestment Act of 2009) and a rise in new vehicle sales (spurred by the "Cash for Clunkers" program) helped to boost activity in the automotive and construction markets, which use galvanized sheet and zinc alloys.

Prices and Stocks

The annual average London Metal Exchange, Ltd. (LME) cash price for SHG zinc in 2009 declined by 13% from that of 2008 to $1,654.69 per metric ton (75.06 cents per pound). The monthly average price was $1,187 per metric ton in January and rose to $2,375 per metric ton in December. Despite the zinc metal market being in surplus during 2009, average monthly zinc prices increased, possibly owing to speculative investment as overall economic conditions improved during the year.

The annual average Platts North American producer price for SHG zinc in 2009, which was based on the LME cash price plus a premium, was 77.91 cents per pound. Monthly average North American SHG premiums began the year at approximately 3.10 cents per pound and decreased to about 2.75 cents per pound in July, after which premiums rose slightly to approximately 2.85 cents per pound by yearend.

Yearend stocks of SHG zinc in global LME warehouses increased to 489,125 t from 253,475 t at yearend 2008. Much of the increase during the year was from rising zinc inventories at U.S. warehouses—mainly in New Orleans, LA, and Detroit, MI.

World Industry Structure

Global zinc mine production decreased by 3% in 2009 from that of 2008 to approximately 11.2 Mt (table 10) as a result of numerous production cutbacks and mine closures. Production increases in several countries were not able to compensate for the significant production decreases in Australia, China, Peru, Poland, Portugal, and the United States. China (28% share of global production), Peru (13%), and Australia (12%) were the three leading producers of zinc in concentrate in 2009. Mine openings during the year, which added 314,000 t/yr of capacity, were more than offset by closures or cutbacks. Significant mine openings included Goldcorp Inc.'s Penasquito polymetallic mine in Mexico (190,000 t/yr zinc in concentrate production capacity) and Iberian Minerals Corp.'s Aguas Tenidas copper-zinc-lead mine in Spain (58,000 t/yr of zinc in concentrate production capacity). Permanent and temporary mine closures reduced active production capacity by 477,000 t/yr. However, much of this reduction was temporary; 390,000 t/yr of capacity was expected to reopen in the near future (International Lead and Zinc Study Group, 2010b; 2011, p. 6).

Global zinc metal production decreased by 3% in 2009 from that of 2008 to 11.2 Mt (table 11) owing to voluntary production cutbacks at many smelters outside of China that were implemented to prevent an accumulation of zinc metal stocks. China (38% share of global production), Canada (6%), and Japan (6%) were the leading producers of refined zinc metal in 2009.

After declining since the third quarter of 2008, global zinc consumption began to recover during the second quarter of 2009. According to the International Lead and Zinc Study Group (ILZSG) data, annual global zinc consumption declined by 5% in 2009 from that of 2008 to 10.8 Mt. Consumption decreases in Europe (25%), Japan (23%), the Republic of Korea (22%), and the United States (11%) were moderated by an 18% increase in China (International Lead and Zinc Study Group, 2010b).

Outlook

Global economic activity was expected to continue to strengthen throughout the first half of 2010. In April 2010, ILZSG forecast an 11% increase in zinc consumption in 2010 from that in 2009 owing to increases in consumption in Europe, Japan, and the United States. China's consumption was expected to rise by 9% owing to continued expenditure on infrastructure and strong growth in the automotive and construction sectors (International Lead and Zinc Study Group, 2010a).

On the supply side, mine production was expected to increase by 6% in 2010 to 12.05 Mt owing to the reversal of mine suspensions and production curtailments that took place in 2009. Refined metal production was expected to increase by 10% to 12.5 Mt owing to the reversal of voluntary production curtailments at many Western smelters, the opening of Hindustan Zinc Ltd.'s Rajpura Dariba refinery in India, and China's estimated 11% increase in production. Overall, the zinc metal market was forecast to remain in substantial surplus in 2010 (International Lead and Zinc Study Group, 2010a).

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TABLE 1

SALIENT ZINC STATISTICS[1]

		2005	2006	2007	2008	2009
United States:						
Production:						
Domestic ores, contained zinc	metric tons	748,000	727,000	803,000	778,000	736,000
Domestic ores, recoverable zinc	do.	720,000	699,000	769,000	748,000	710,000
Value, recoverable zinc	thousands	$1,070,000	$2,450,000	$2,620,000	$1,470,000	$1,220,000
Refined zinc:						
At primary smelters	metric tons	195,000 e	113,000	121,000	125,000	94,000
At secondary smelters[e]	do.	156,000	156,000	157,000	161,000	109,000
Total	do.	351,000	269,000	278,000	286,000	203,000
Exports:						
Ores and concentrates, zinc content	do.	786,000	825,000	816,000	725,000	785,000
Refined (slab) zinc	do.	784	2,530	8,070	3,250	2,960
Zinc plates, sheets, strip, and foil	do.	8,760	3,780	4,310	4,970	6,160
Imports for consumption:						
Ores and concentrates, zinc content	do.	156,000	383,000	271,000	63,200	74,200
Refined (slab) zinc	do.	700,000	895,000	758,000	725,000	686,000
Zinc plates, sheets, strip, and foil	do.	3,630	2,050	2,160	3,330	3,010
Reported stocks of slab zinc, December 31:						
Producer and consumer	do.	71,100	60,000 r	55,000 r	56,000 r	49,000
Government stockpile	do.	45,100	15,300	7,730	7,490	7,490
Consumption, refined zinc:						
Reported	do.	466,000 r	501,000 r	436,000 r	370,000 r	306,000
Apparent[2]	do.	1,080,000	1,190,000 r	1,040,000	1,010,000 r	893,000
Price[3]						
North American	cents per pound	67.11	158.89	154.40	88.93	77.91
London Metal Exchange, cash	do.	62.66	148.53	147.03	85.01	75.06
World production:						
Mine	thousand metric tons	10,000	10,300	11,000	11,600 r	11,200
Smelter	do.	10,300 r	10,800 r	11,400 r	11,700 r	11,400

[e] Estimated. [r] Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits, except prices; may not add to totals shown.

[2] Domestic production plus net imports, plus adjustments for Government and industry stock changes.

[3] Special High Grade. Source: Platts Metals Week.

TABLE 2
MINE PRODUCTION OF RECOVERABLE ZINC IN THE UNITED STATES, BY STATE[1]

(Metric tons)

State	2008	2009
Alaska[2]	588,000	661,000
Other	160,000 [3]	49,600 [4]
Total	748,000	710,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Data based, in part, on publicly available information.

[3] Includes production from Idaho, Missouri, Montana, New York, Tennessee, and Washington.

[4] Includes production from Idaho, Missouri, Montana, Tennessee, and Washington.

TABLE 3
LEADING ZINC-PRODUCING MINES IN THE UNITED STATES IN 2009, IN ORDER OF OUTPUT[1]

Rank	Mine	County and State	Operator	Source of zinc
1	Red Dog	Northwest Arctic, AK	Teck Alaska Inc.	Zinc-lead ore.
2	Greens Creek	Juneau, AK	Hecla Mining Co.	Zinc-silver ore.
3	Brushy Creek	Reynolds, MO	Doe Run Resources Corp.	Lead ore.
4	Lucky Friday	Shoshone, ID	Hecla Mining Co.	Silver ore.
5	Buick	Iron, MO	Doe Run Resources Corp.	Lead ore.
6	Pend Oreille	Pend Oreille, WA	Teck Washington Inc.	Zinc-lead ore.
7	Fletcher	Reynolds, MO	Doe Run Resources Corp.	Lead ore.
8	Montana Tunnels	Jefferson, MT	Apollo Gold Corp.	Gold ore.
9	East Tennessee Zinc Complex[2]	Jefferson and Knox, TN	Glencore International AG	Zinc ore.
10	Viburnum (#29 and #35)	Washington and Iron, MO	Doe Run Resources Corp.	Lead ore.

[1] The mines on this list accounted for more than 99% of recoverable U.S. zinc mine production in 2009.

[2] Coy, Immel, and Young Mines. In December 2009, Nyrstar NV (Brussels, Belgium) acquired the East Tennessee Zinc Complex from Glencore.

TABLE 4
REPORTED PRODUCTION OF ZINC PRODUCTS FROM ZINC-BASE SCRAP IN THE UNITED STATES[1]

(Metric tons)

Products	2008	2009
Redistilled slab zinc	171,000	115,000
Other zinc metal products[2]	1,880	1,540
Zinc in chemical products	W	W
Zinc dust	26,300	22,200

W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Includes electrogalvanizing anodes, remelt die-cast slab, and other metal alloys.

TABLE 5
ZINC RECOVERED FROM SCRAP PROCESSED IN THE UNITED STATES, BY TYPE OF SCRAP[1]

(Metric tons)

	2008	2009
Type of scrap:		
New scrap:		
Zinc-base	126,000 [r]	82,900
Copper-base	121,000 [r]	111,000
Magnesium-base	107 [r]	100
Total	246,000 [r]	194,000
Old scrap:		
Zinc-base	83,300	70,000
Copper-base	9,020 [r]	8,220
Aluminum-base	582 [r]	498
Magnesium-base	14	14
Total	92,900 [r]	78,800
Grand total	339,000 [r]	273,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 6
U.S. REPORTED CONSUMPTION OF ZINC IN 2009, BY INDUSTRY USE AND GRADE[1]

(Metric tons)

Industry use	Special high grade	High grade	Prime western	Remelt and other grades	Total
Galvanizing	97,300	39,000	34,500	55,000	226,000
Zinc-base alloys	W	W	--	--	17,900
Brass and bronze	W	W	W	--	45,500
Other	16,100	W	W	--	17,200
Total	170,000	46,600	34,600	55,000	306,000

-- Zero.

W Withheld to avoid disclosing company proprietary data; included in "Total."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 7
U.S. EXPORTS OF ZINC ORES AND CONCENTRATES, BY COUNTRY[1]

	2008		2009	
	Quantity (metric tons, zinc content)	Value (thousands)	Quantity (metric tons, zinc content)	Value (thousands)
Aruba	1	$6	--	--
Australia	--	--	27,400	$19,500
Belgium	53,000	35,200	27,400	25,600
Canada	261,000	277,000	226,000	151,000
Chile	73	70	--	--
China	69,900	57,200	44,900	43,900
Denmark	--	--	5	3
El Salvador	--	--	3	12
Finland	39,600	25,200	26,500	26,600
Germany	33,600	35,600	6,090	4,330
India	68	114	104	90
Israel	29	19	--	--
Italy	1	12	42,700	40,500
Japan	119,000	66,700	79,600	59,600
Korea, Republic of	116,000	85,200	189,000	167,000
Mexico	--	--	12	15
Panama	--	--	(2)	3
Saudi Arabia	9	15	--	--
Spain	32,600	14,900	116,000	118,000
Suriname	--	--	1	4
United Kingdom	68	78	46	26
Total	725,000	598,000	785,000	656,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8
U.S. EXPORTS OF ZINC COMPOUNDS[1]

	2008		2009	
	Quantity (metric tons, gross weight)	Value (thousands)	Quantity (metric tons, gross weight)	Value (thousands)
Chromates of zinc or of lead	17	$157	56	$293
Lithopone	350	1,400	666	3,000
Zinc chloride	1,840 r	2,110	1,800	2,750
Zinc oxide	39,900	61,700	17,300	31,100
Zinc sulfate	578	799	1,030	1,610
Zinc sulfide	6,850	10,300	4,510	8,720

r Revised.

[1] Data are rounded to no more than three significant digits.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF ZINC COMPOUNDS[1]

	2008		2009	
	Quantity (metric tons, gross weight)	Value (thousands)	Quantity (metric tons, gross weight)	Value (thousands)
Chromates of zinc or of lead	298	$1,310	32	$101
Lithopone	1,850	1,960	1,550	1,520
Zinc chloride	462	1,780	249	964
Zinc oxide	114,000	192,000	69,200	98,500
Zinc sulfate	41,900	45,700	31,700	23,000
Zinc sulfide	2,450	4,380	1,570	2,990

[1] Data are rounded to no more than three significant digits.

Source: U.S. Census Bureau.

TABLE 10
ZINC: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, zinc content of concentrate and direct shipping, unless otherwise specified)

Country	2005	2006	2007	2008	2009
Algeria	4,412 [r]	572 [r]	--	--	--
Argentina	30,227	29,808	27,025	30,349 [r]	30,000 [e]
Armenia[e]	3,000	2,932 [3]	2,585 [3]	4,200	3,900
Australia	1,367,000	1,362,000	1,514,000	1,519,000 [r]	1,290,000
Bolivia	158,582 [r]	172,747	214,053 [r]	383,618	421,721
Bosnia and Herzegovina[e]	3,000	1,000	2,000	5,000 [r]	2,000
Brazil	170,659	185,211	193,887	173,933	174,000 [r]
Bulgaria[e]	17,500	13,476 [3]	12,206 [3]	12,200	12,000
Burma	78 [4]	46	10	20	45
Canada	666,654	637,956	622,985	716,078	698,901
Chile	28,841 [4]	36,238	36,453	40,519	27,801
China	2,550,000	2,840,000	3,040,000	3,200,000	3,100,000
Congo (Kinshasa)	7,588	16,831	18,500	18,000 [e]	16,000
Finland	40,500	35,700	38,900	27,800	30,233
Georgia[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
Greece	1,300	16,414	19,549	22,694	18,126
Guatemala	--	6,000	20,000	14,000	--
Honduras	42,698	37,646	29,211	28,462	36,370
India	477,100	501,700	538,900	613,600	695,000
Iran[e]	167,000	164,000	100,000	100,000	100,000
Ireland	429,464	425,756	400,898	398,158	385,670
Japan	41,452	7,169	--	--	--
Kazakhstan	364,300	404,600	446,000	459,000	480,000
Korea, North[e]	65,000	85,000	95,000	65,000	65,000
Korea, Republic of	77	16	4,067 [r]	3,672 [r]	4,000 [e]
Kosovo[5]	430 [r]	2,230 [r]	2,460 [r]	4,900 [r]	3,690
Laos	3,410	1,100	1,100	1,100 [e]	1,000 [e]
Macedonia	--	11,000	24,000 [r]	29,000 [r]	32,000
Mexico	476,307	432,347	426,509	397,306	390,000 [e]
Mongolia	11,400	54,850	77,350	71,800 [r]	72,000 [e]
Morocco	128,000	95,000	57,700	96,900	98,000
Namibia[6]	69,368	55,455	46,335 [r]	38,319 [r]	38,300 [e]
Peru	1,201,671	1,203,364 [r]	1,444,381 [r]	1,602,597	1,509,129
Philippines	--	--	7,364	1,619 [r]	10,035

See footnotes at end of table.

TABLE 10—Continued
ZINC: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, zinc content of concentrate and direct shipping, unless otherwise specified)

Country	2005	2006	2007	2008	2009
Poland	135,600	126,000	124,000	125,000	100,000 [e]
Portugal	--	7,505	24,380	39,254 [r]	501
Romania	13,784	8,052	1,000	-- [r]	--
Russia[e]	180,000	190,000	185,000	204,000	225,000
Saudia Arabia	--	983	716	3,663	4,500 [e]
Serbia	1,000 [7]	2,000	1,000	1,000 [e]	1,000 [e]
South Africa	32,112	34,444	30,859 [r]	29,002 [r]	28,159
Spain	--	--	--	--	6,500 [e]
Sweden	215,691	210,029	214,576	188,048 [r]	192,538
Thailand	47,250	32,100 [r]	32,921 [r]	17,811 [r]	34,000
Tunisia	15,889	--	--	--	--
Turkey	56,000	59,000	71,000	73,000	76,000 [e]
United States	748,000	727,000	803,000	778,000	736,000
Vietnam[e]	48,000	45,000	46,000	45,000	45,000
Total	10,000,000	10,300,000	11,000,000	11,600,000 [r]	11,200,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 7, 2010.

[3] Reported figure.

[4] Data are for fiscal year ending March 31 of the following year.

[5] On February 17, 2008, the Kosovo Assembly declared independence from Serbia.

[6] Does not include ores sent to solvent extraction-electrowinning plant.

[7] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

TABLE 11

ZINC: WORLD SMELTER PRODUCTION, BY COUNTRY[1,2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009
Algeria, primary[e]	32,000 [4]	30,000	30,000	30,000	30,000
Argentina:					
Primary	37,460	42,584	42,876	39,479 [r]	40,000 [e]
Secondary	2,997	3,407	3,430	3,158 [r]	3,000 [e]
Total	40,457	45,991	46,306	42,637 [r]	43,000 [e]
Australia:					
Primary[5]	457,300	463,000	502,000	499,000	525,000
Secondary[e]	6,000 [r]	6,000 [r]	6,000 [r]	6,000 [r]	6,000
Total	463,300 [r]	469,000 [r]	508,000 [r]	505,000 [r]	531,000
Belgium, primary	257,000 [e]	251,000	241,000	251,000 [r]	26,000
Brazil, primary	267,374	272,311 [r]	265,126	248,874 [r]	250,000 [p,e]
Bulgaria, primary and secondary	92,077	95,341	99,992	102,000 [r]	92,000
Canada, primary	724,035	824,464	802,103	764,312	685,504
China, primary and secondary[e]	2,780,000	3,170,000	3,740,000	4,000,000	4,360,000
Czech Republic, secondary[e]	250	250	250	250	250
Finland, primary	281,904	282,238	305,543	297,722	295,000
France, primary	267,524	127,777	129,110	117,861	161,000
Germany, primary and secondary	344,891	342,566	294,735	292,284	159,000 [e]
India:					
Primary	266,200	420,900	430,800	545,800	560,000 [p]
Secondary[e]	23,000	23,000	23,000	22,000	22,000
Total	289,200	443,900	453,800	567,800	582,000
Iran[e]	120,000	140,000	90,000	100,000	100,000
Italy, primary and secondary[e]	121,000 [4]	109,000 [4]	109,000	100,000	100,000
Japan:					
Primary	536,768	504,532 [r]	501,135	509,717 [r]	515,000 [e]
Secondary	138,453	148,715	137,560	122,859 [r]	128,000 [e]
Total	675,221	653,247 [r]	638,695	632,576 [r]	643,000 [e]
Kazakhstan, primary and secondary	364,821	364,821	358,226	365,561	328,834
Korea, North, primary and secondary[e]	72,000	72,000	75,000	75,000	75,000
Korea, Republic of, primary	644,828	662,521	690,000 [r]	738,000 [r]	623,000 [e]
Kosovo, primary[6]	--	--	--	--	5,487
Mexico, primary	327,205	279,734	321,932	305,409	300,000 [e]
Namibia[7]	132,800	129,900	150,080	145,400	150,400
Netherlands, primary	224,549	238,274	224,838	239,462	224,000 [e]
Norway, primary	151,285	160,670	157,027	145,469	138,973
Peru, primary	163,603	175,250	162,375	190,324	179,224
Poland, primary and secondary	137,300	134,000	142,000	143,000 [r,e]	140,000 [e]
Portugal, secondary[e]	2,000	--	--	--	--
Romania, primary and secondary	57,000 [e]	43,705	58,342	62,000 [r]	1,000
Russia, primary and secondary[e]	220,000	240,000	260,000	260,000	225,000
Serbia, primary and secondary[e]	1,800 [4,8]	15,000 [4]	--	--	--
South Africa, primary	102,000	90,000	101,000	87,000	87,000 [e]
Spain, primary and secondary	506,230	507,440	494,090	456,050	500,776
Thailand, primary	60,866 [r]	94,779 [r]	99,337 [r]	107,753 [r]	100,000 [e]
United States:					
Primary	195,000 [e]	113,000	121,000	125,000	94,000
Secondary[e]	156,000	156,000	157,000	161,000	109,000 [e]
Total	351,000	269,000	278,000	286,000	203,000

See footnotes at end of table.

TABLE 11—Continued
ZINC: WORLD SMELTER PRODUCTION, BY COUNTRY[1, 2]

Country[3]	2005	2006	2007	2008	2009
Uzbekistan, primary	35,030	45,000 e	71,800	70,445	40,000 e
Grand total	10,300,000 r	10,800,000 r	11,400,000 r	11,700,000 r	11,400,000
Of which:					
Primary	5,030,000 r	5,080,000	5,200,000 r	5,310,000 r	4,880,000
Secondary	329,000 r	337,000 r	327,000 r	315,000 r	269,000
Undifferentiated	4,950,000	5,360,000	5,870,000	6,100,000 r	6,230,000

eEstimated. pPreliminary. rRevised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Wherever possible, detailed information on raw material source of output (primary—directly from ores, and secondary—from scrap) has been provided. In cases where raw material source is unreported and insufficient data are available to estimate the distribution of the total, that total has been left undifferentiated (primary and secondary). To the extent possible, this table reflects metal production at the first measurable stage of metal output. Table includes data available through June 23, 2010.

[3] In addition to the countries listed, Israel also produces small amounts of secondary zinc, but available information is inadequate to make reliable estimates of output levels.

[4] Reported figure.

[5] Excludes zinc dust.

[6] On February 17, 2008, the Kosovo Assembly declared independence from Serbia.

[7] Special high-grade electrowon cathodes from Anglo American plc's Skorpian solvent extraction-electrowinning plant.

[8] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

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ZIRCONIUM AND HAFNIUM

By Joseph Gambogi

Domestic survey data and tables were prepared by Connie Lopez, statistical assistant, and the world production table was prepared by Linder Roberts, international data coordinator.

In 2009, global economic conditions continued to depress zircon consumption. In response to decreased demand, zircon producers curtailed production and delayed some expansion programs.

World production of zirconium mineral concentrates in 2009, excluding U.S. production, was about 1.16 million metric tons Mt) compared with 1.28 Mt in 2008. The primary source of zirconium was the mineral zircon ($ZrSiO_4$) principally found in heavy-mineral sands. A relatively small quantity of zirconium was derived from the mineral baddeleyite, a natural form of zirconium oxide (ZrO_2) produced from a single source at Kovdor, Russia. In 2009, the leading producers of zircon were Australia and South Africa. Zircon is also the primary source of hafnium; zirconium and hafnium are contained in zircon at a atio of about 50 to 1. The leading producers of zirconium and hafnium metal were France, Russia, and the United States.

Because of economic conditions, U.S. production of milled zircon decreased significantly compared with that of 2008. The United States remained a net exporter of zirconium ore and concentrates. U.S. exports of zirconium ore and concentrate decreased by 6%, and imports of zirconium ore and concentrates decreased by 58% compared with those of 2008. With the exception of prices and referenced data, all survey data in this report have been rounded to no more than three significant digits. Totals and percentages were calculated from unrounded numbers.

Production

Zircon is a coproduct of the mining and processing of heavy-mineral sands for the titanium minerals ilmenite and rutile. n 2009, U.S. producers of zircon were DuPont Titanium Technologies (DuPont) (a subsidiary of E.I. du Pont de Nemours & Co.) and Iluka Resources, Inc. (a subsidiary of Australian company Iluka Resources Ltd.). DuPont produced zircon from its heavy-mineral sands operation near Starke, FL. Iluka produced zircon from its heavy-mineral sands operations at Stony Creek, VA.

Data for zirconium and hafnium manufactured materials were developed by the U.S. Geological Survey (USGS) from a voluntary survey of domestic operations. Of the 41 operations surveyed, 20 responded. Data for nonrespondents were estimated on the basis of prior-year levels adjusted for the effect of economic conditions. Domestic production of milled zircon was 38,400 metric tons (t). Domestic production of zircon concentrate n 2009 decreased compared with that of 2008. Insufficient data were available to determine stocks of zircon and zirconium oxide as well as production of zirconium oxide (table 1).

Data for zircon concentrates were developed from a second voluntary survey of domestic mining operations. The two domestic zircon producers responded. Data on domestic production and consumption of zircon concentrates were withheld to avoid disclosing company proprietary data.

Iluka commenced mining at its Brink deposit in Virginia to support the continued operation of its Stony Creek mining operations. The Brink deposit is about 48 kilometers south of the Stony Creek mining operations. The development of the Brink deposit was expected to extend the life of the Virginia operations to 2015. At Green Cove Springs, FL, Iluka ceased reprocessing of stockpiled tailings (Iluka Resources Ltd., 2010, p. 2, 44).

U.S. producers of zirconium and hafnium metal were ATI Wah Chang (an Allegheny Technologies, Inc. business unit) in Albany, OR, and Western Zirconium (a subsidiary of Westinghouse Electric Co.) in Ogden, UT. Milled zircon (flour) was produced from zircon sand by at least five companies, and zirconium chemicals were produced by about a dozen companies.

Wah Chang was increasing its zirconium sponge production and vacuum arc remelting (VAR) capacity at its Albany facility. The company cited anticipated growth in consumption in the chemical processing industry and nuclear energy industries as the motivation to increase capacity. In the nuclear industry, zirconium and hafnium alloys are used in nuclear fuel cladding and structural components (Allegheny Technologies Inc., 2010, p. 3). The additional capacity was expected to increase domestic zirconium sponge capacity to about 5,800 metric tons per year (t/yr).

Westinghouse Electric Co. formed an agreement with the State Nuclear Power Technology Co., Ltd. (SNPT) to construct a nuclear-grade zirconium sponge plant at Nantong, Jiangsu Province, China. The plant was expected to supply nuclear-grade sponge to Westinghouse's Western Zirconium Plant in Ogden and the market in China. SNPT expected to produce up to 1,000 t/yr of nuclear sponge within 3 years (World Nuclear News, 2009).

Industrial Minerals Corp. (IMC) received a mining permit from Oregon Department of Geology and Mineral Industries for its Coos Bay, OR, heavy-minerals project. Once financing is secured, IMC expected to begin producing chromite, garnet, and zircon within a year. Estimated proven ore reserves at Coos Bay were 7.9 Mt with a heavy-mineral grade of 21.5% and zircon grade of 0.4% (Industrial Minerals Corp. Ltd., 2009, p. 4, 12).

Consumption

Major end uses of zircon were ceramics, zirconia and zirconium chemicals, and foundry and refractories. Global consumption of zircon was estimated to be 0.99 Mt in 2009, significantly less than the estimated 1.3 Mt consumed in 2008 (Mineral Sands Report, 2010b). According to a leading zircon producer, the leading end uses for zircon in 2008 were ceramics (54%), zirconia and chemicals (15%), refractory (14%), and foundry and casting (14%) (Porter, 2010, p. 8). Zircon is also used as a natural gemstone and may be processed to produce cubic zirconia, a synthetic gemstone and diamond simulant.

Zirconium metal is used in corrosive environments, nuclear fuel cladding, and various specialty alloys. The principal uses of hafnium were in high-temperature ceramics, nickel-base superalloys, nozzles for plasma arc metal cutting, and nuclear control rods.

Zirconium oxide exhibits high light reflectivity and good thermal stability and is primarily used as an opacifier and pigment in glazes and colors for pottery and other ceramic products. Yttria-stabilized zirconia (YSZ) was used in the manufacture of oxygen sensors that control combustion in automobile engines and furnaces. YSZ was also used in the manufacture of a diverse array of products, including cubic zirconia, fiber optic connector components, refractory coatings, and structural ceramics. YSZ was used in dental applications, such as bridges, crowns, and inlays, because it has two to three times the fracture resistance and 1.4 times the strength of similar alumina products.

Zircon, used for facings on foundry molds, increases resistance to metal penetration and gives a uniform finish to castings. Milled or ground zircon was used in refractory paints for coating the surfaces of molds. In the form of refractory bricks and blocks, zircon was used in furnaces and hearths for containing molten metals. Glass tank furnaces use fused-cast and bonded alumina-zirconia-silica-base refractories. Baddeleyite is used principally in the manufacture of alumina-zirconia abrasive and in ceramic colors and refractories.

Ammonium- and potassium-zirconium carbonates were used as paper and board coatings or insolubilizers for high-quality print performance. Zirconium chemicals were also used in inks to promote adhesion to metals and plastics and as crosslinkers in polymers and printing inks.

Because of its low thermal neutron absorption cross section, hafnium-free zirconium metal is used as cladding for nuclear fuel rod tubes. Hafnium is used in nuclear control rods because of its high thermal neutron absorption cross section. Commercial-grade zirconium, unlike nuclear grade, contains hafnium and was used in the chemical process industries because of its excellent corrosion resistance. Hafnium metal also is used as an alloy addition in superalloys. The French zirconium metal producer Cezus (a subsidiary of Areva NP) estimated the global zirconium metal consumption to be about 5,000 t (Desai, 2009a).

Prices

Despite a significant reduction in consumption, prices of zirconium ores and concentrates increased in 2009. At yearend, the published price range of standard grade, bulk, free-on-board, Australian zircon was $880 to $900 per metric ton, up from $725 to $800 per ton at yearend 2008 (table 2). The unit value of imports also increased. Although the import volume decreased by 58%, the average unit value of imported zirconium ore and concentrates was $1,190 per ton in 2009, a 35% increase from that in 2008. Increased prices appeared to indicate a recovery in demand in the second half of the year.

No published prices were available for zirconium metal. In 2009, the average unit value of imported unwrought zirconium including sponge and powder from France was $51.50 per kilogram, a 27% increase from that in 2008. The average unit value of imported unwrought hafnium including sponge and powder from France was $472 per kilogram, a 110% increase from that in 2008.

Foreign Trade

In 2009, Australia (56%) and South Africa (35%) supplied most of the imports of ores and concentrates, and the United States remained a net exporter of zirconium ore and concentrates (table 4). Net exports of zirconium ore and concentrates increased significantly, reflecting the sharp decrease in domestic consumption (table 3). The majority of zirconium metal was exported in wrought products classified as "Other zirconium" in the Harmonized Tariff Schedule category 8109.90.0000. Because of weak economic conditions, imports of zirconium and hafnium metal were less than 1,000 t. Imports of zirconium and hafnium metal decreased by 5% and 58%, respectively, compared with those of 2008. Imports of germanium and zirconium oxides decreased significantly, with China (50%) as the leading import source of oxides. Because of weakening demand in the steel industry, domestic imports of ferrozirconium alloys plummeted to 0.249 t in 2009 from the 129 t imported in 2008. In 2008 and 2009, all ferrozirconium imports originated from Brazil.

World Review

Excluding U.S. production, world production of zirconium mineral concentrates in 2009 was about 1.16 Mt, a 9% decrease compared with revised 2008 data (table 5). Australia and South Africa supplied about 75% of all production outside the United States. China was the leading consumer. Based on metal oxide content, world reserves of zirconium and hafnium were estimated to be 56 Mt and 660,000 t, respectively. In 2009, several producers idled or curtailed mine production. Exploration and development continued but several projects were postponed. Major zircon producers were Iluka, Richards Bay Minerals (BHP Billiton plc/Rio Tinto plc), Exxaro Resources Ltd., The National Titanium Dioxide Co. Ltd. (Cristal Global), and DuPont.

Australia.—Iluka began production of zircon at its Jacinth-Ambrosia Mine in the Eucla Basin, South Australia. During its mine life of more than 10 years, Jacinth-Ambrosia was expected to produce approximately 2.8 Mt of zircon, 350,000 t of rutile, and [illegible] Mt of ilmenite (Iluka Resources Inc., 2009b). In Western Australia, Iluka idled its Eneabba Mine because of declining ore grades and the opening of the Jacinth-Ambosia Mine. In 2009, Iluka was in the process of upgrading the Narngulu mineral separation plant to process heavy-mineral concentrate from the Jacinth-Ambrosia concentration plant (Iluka Resources Inc., 2009a).

The Australian Nuclear Science and Technology Organisation's Minerals Business Unit produced sample quantities of zirconium chemicals from ore extracted from Alkane Resources Ltd.'s zircon-rich mineral deposit near Dubbo, New South Wales. In 2009, Alkane Resources was refining its designs to recover niobium-tantalum, rare earth, and zirconium chemicals and concentrates (Alkane Resources Ltd., 2009, p. 11).

The Australian Government approved Astron Ltd.'s environmental plan for the development of its Donald heavy-minerals deposit in the Murray Basin, Victoria. Astron planned to produce heavy-mineral concentrate from Donald and then process the concentrate through a mineral sand separation plant in China

(Astron Ltd., 2009, p. 6). According to Astron, the deposit contained an indicated and inferred resource of ilmenite (8.5 Mt), leucoxene (5.4 Mt), zircon (5.2 Mt), and rutile (1.2 Mt) (Astron Ltd., undated).

Australian Zircon NL's suspended mining activities at its Mindarie operation in South Australia, and the company went into administration to obtain relief from its creditors. During 2009, the company continued a feasibility study of the WIM150 deposit and produced ilmenite, rutile, and zircon from previously mined ore hrough yearend (Mineral Sands Report, 2009a). Although no data were available for 2009, in 2008, the Mindari operation produced about 6,000 t of zircon (Geoscience Australia, 2009, p. 48).

Mintech Chemical Industries Pty. Ltd. acquired Doral Specialty Chemicals Pty. Ltd. (DSC) from the Doral Group. DSC's assets included zircon-based pigments mixing and zircon milling capacity as well as a zirconium chemicals operation in Kwinana, Western Australia, which was idle since 2008. Doral retained ownership of its heavy-mineral mining operations near Picton, Western Australia, and fused zirconia and alumina operations in Rockingham, Western Australia (Industrial Minerals, 2009).

In May, Unimin Australia Ltd. acquired Consolidated Rutile Ltd. (CRL) from Iluka. In 2009, the CRL Mine on North Stradbroke Island, Queensland, was estimated to contain 3.2 Mt of heavy-minerals with a heavy-mineral suite containing lmenite, rutile, and zircon (Mineral Sands Report, 2009c).

Gunson Resources Ltd. completed a feasibility study for its Coburn heavy-minerals project in Western Australia. The project was ready to proceed to the mine development stage and was expected to have a life of 23.5 years. Most of the revenue from he proposed mine was expected to be from zircon production Mineral Sands Report, 2010a).

Matilda Zircon Ltd. was developing zircon-rich heavy-minerals deposits in the Tiwi Islands, Northern Territory. In 2009, the Tiwi Islands operation included a 150-metric-ton-per-hour concentration plant but did not include a separation plant. A new mine at the Lethbridge deposit, Melville Island, was expected to be in production by mid-2010. Although no production data were available for 2009, in 2008, the Tiwi Islands operation produced 46,000 t of heavy-mineral concentrate grading 50% zircon that was shipped to China Matilda Zircon Ltd., 2009a, b).

Canada.—Sustainable Development Technology Canada awarded Titanium Corp.'s "Creating value from waste" project $4.9 million in funding. The award was expected to promote echnologies that recover bitumen and heavy minerals including zircon from oil sands tailings. Consortium members of the project included Sojitz Corp., Syncrude Canada Ltd., Titanium Corp., and the Government of Alberta (Titanium Corp., 2009).

China.—As a leading producer of ceramic tiles, steel, and irconium chemicals, China was estimated to consume about 40% of the total global zircon consumed. Zircon consumption growth in China from 1990 to 2008 was estimated to be 17.2%, and tile production primarily supported domestic uses (Porter, 2010, p. 7).

In 2009, zirconium chemical production capacity in China was stimated to be 200,000 t/yr, and about 90% of production was in he form of zirconium oxychloride (Mineral Sands Report, 2009b).

Hainan Taixin Minerals Co. Ltd. acquired mining rights to a heavy-mineral deposit near Wanning City, Hainan Province. The deposit was reported to have a proven reserve of zircon (0.5 Mt) and ilmenite (2.24 Mt). While granting the mining rights, the Provincial government stipulated that the company would be required to produce added-value products beyond ilmenite and zircon concentrates (Mineral Sands Report, 2009d).

India.—India's Department of Atomic Energy commissioned zirconium oxide and zirconium sponge capacity at its zirconium complex in Pazhayakayal, Tamil Nadu. About 500 t/yr of zirconium oxide capacity via solvent extraction and 250 t/yr of zirconium sponge capacity via Kroll reduction were being added primarily for use in nuclear applications. The expansion was expected to raise India's total zirconium sponge capacity to 650 t/yr from 400 t/yr (Indian Department of Atomic Energy, 2010, p. 4).

Indonesia.—In September, Matilda Zircon entered into a memorandum of understanding with PT Makmur Santosa Energi to develop zircon-rich areas in Kalimantan. Pending the results of a due diligence study, Matilda Zircon planned to relocate its heavy-mineral concentration plant from Sampit to central Kalimantan. The Sampit concentration plant was reported to have a capacity of 7,000 t/yr of heavy-mineral concentrate containing about 64% zircon. Once relocated, the plant was expected to produce up to 12,000 t/yr of heavy-mineral concentrate (Matilda Zircon Ltd., 2009a).

Kenya.—In August, the Jinchuan Group Ltd. entered into an understanding with Tiomin Resources Inc. wherein Jinchuan was to acquire 70% of Tiomin Kenya Ltd. (TKL) mineral sands project; however, in October, Jinchuan terminated the agreement. At yearend, Tiomin abandoned plans to develop the deposit and wrote off all the costs associated with the Kwale project. Subsequent to yearend, Tiomin changed its name to Vaaldiam Mining Inc. (Vaaldiam Mining Inc., 2010).

Mozambique.—BHP Billiton completed a prefeasibility study of the Corridor Sands heavy-minerals project. BHP concluded that the results of the study did not warrant further development of the project (BHP Billiton Ltd., 2009, p. 33). The Corridor Sands project was based upon 10 deposits near Chibuto in southern Mozambique. Previously, total resources of ore were estimated to be 14 billion metric tons, with the largest deposit containing about 300 Mt of ilmenite.

Russia.—ARMZ Uranium Holding Co. was developing the Lukoyanovskoye heavy-minerals sands deposit near Nizhny Novgorod. ARMZ planned to commission a mine and processing plant with the annual capacity to process up to 1.5 billion metric tons per year of ore sands by 2014. According to the Russian classification system, ore reserves in categories "C1" and "C2" were estimated to be 30 Mt containing about 1 Mt of titanium in the form of ilmenite, leucoxene, and rutile and more than 350,000 t of zirconium oxide in the form of zircon. ARMZ planned to supply mineral concentrates to OJSC TVEL (ARMZ Uranium Holding Co., 2009).

Senegal.—A feasibility study of Mineral Deposits Ltd.'s Grande Cote deposit was underway in 2009. The study was expected to be completed in 2010 and was to include updated capital costs, circuit model test work, financial modeling, geological block modeling, hydrological modeling, and mine path design (Mineral Deposits Ltd., 2010b). The company planned to produce up to 75,000 t/yr of zircon and 600 t/yr of ilmenite for mine life of more than 25 years (Mineral Deposits Ltd., 2010a).

South Africa.—In April, Foskor Zirconia Pty. Ltd. temporarily suspended its fused zirconia operations because of weak demand from the steel industry; however, by May, the operation was restarted with a more diverse product line directed toward wear applications and the glass industry. In 2008, Foskor Zirconia was acquired by Carborundum Universal Ltd. and increased its production capacity to 4,500 t/yr from 3,750 t/yr of calcia-stabilised and monoclinic zirconia (Mining Weekly, 2009).

Vietnam.—In an effort to assist the domestic mining industry, the Government of Vietnam temporarily lifted a ban on exports of titanium and zirconium mineral concentrates. Producers were permitted to export from mid-2009 through the end of 2010. The ban had been imposed to encourage the production of value-added products. In 2008, the export tariff for zircon ore was raised to 20% from 15% (Mineral Sands Report, 2009e).

Outlook

Growth in the consumption of zirconium mineral concentrates was expected to increase with demand from consumers such as the ceramics, metals, and chemicals industries. Because the use of these materials is pervasive in the global economy, economic growth may be used to reflect trends in zirconium consumption. The International Monetary Fund projected that world economic growth would be about 4.5% in 2010 and 4.25% in 2011. China was expected to lead global economic growth with 10.5% in 2010 and 9.6% growth expected in 2011. The U.S. economy was projected to increase by 3.3% in 2010 and 2.9% in 2011 (International Monetary Fund, 2010). Over the longer term, the Bureau of Labor Statistics projected the U.S. gross domestic product to average 2.4% growth annually from 2008 to 2018 (Wyatt and Byun, 2009).

Since 2007, several new mines were bought online in Australia, Mozambique, and South Africa ensuring adequate global supply for several years. However, beyond 2013, new mine capacity may be required to meet increased consumption. The stockpiling and destocking of mineral concentrates by consumers, producers, and distributors will continue to influence the price and short-term availability of supply.

Global demand for nuclear powerplants was expected to increase future demand for zirconium and hafnium metal. According to the World Nuclear Association, on a global basis, 47 nuclear powerplants were under construction in June 2009, and another 133 were planned. Although the amount of zirconium metal varies, boiling water reactors were estimated to contain on average about 44 t of zirconium, and pressurized heavy-water reactors require about 12.5 t. Zirconium metal consumption was projected to reach 6,500 t by 2015, a small fraction of the global consumption of zirconium mineral concentrates (Desai, 2009b).

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TABLE 1

SALIENT U.S. ZIRCONIUM STATISTICS[1]

(Metric tons)

	2005	2006	2007	2008	2009
Zircon:					
Production:					
Concentrates	W	W	W	W	W
Milled zircon	46,300	50,800	64,600	61,500	38,400
Exports	101,000	76,300	66,200	42,100	39,600
Imports for consumptions[2]	38,200	36,200	20,000	34,400	14,400
Consumption, apparent[3]	W	W	W	W	W
Stocks, December 31, dealers and consumers[4]	16,100	17,600	18,000	26,600	NA
Zirconium oxide:					
Production[5]	19,900	21,700	25,600	18,100	NA
Exports[6]	2,260	3,340	2,400	2,970	3,050
Imports for consumptions[6]	3,160	2,820	3,740	5,060	2,810
Consumption, apparent[3]	21,000	24,200	26,900	20,400	17,300 [7]
Stocks, December 31, producers[4]	2,210	1,560	1,880	1,670	NA
Zirconium; unwrought powder, waste and scrap, other:					
Exports	1,970	1,880	2,160	2,670	2,300
Imports	1,020	748	784	1,030	977
Ferrozirconium:					
Exports	65	491	259	316	566
Imports	306	196	400	129	(8)
Hafnium, unwrought powder, waste and scrap, other, imports	4	4	4	12	5

NA Not available. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Includes insignificant amounts of baddeleyite.

[3] Defined as production plus imports for consumption minus exports plus or minus Government shipments.

[4] Excludes foundries.

[5] Excludes intermediate oxides associated with metal production.

[6] Includes germanium oxides and zirconium dioxides.

[7] Excludes changes in inventories.

[8] Less than ½ unit.

TABLE 2
PUBLISHED YEAREND PRICES OF ZIRCONIUM MATERIALS

(Dollars per metric ton)

Material	2008	2009
Baddeleyite, contract price, cost, insurance, and freight main European port:		
Refractories/abrasive grade	2,500–3,100	2,500–3,100
Ceramic grade (98% zirconium oxide and hafnium oxide)	3,000–3,300	3,000–3,300
Zircon:		
Domestic, standard-grade, bulk	775–800	800–860
Australian, standard-grade, free on board, bulk	725–820	880–900
Zirconia, fused, monoclinic, refractory/abrasive	NA	4,100–4,900

NA Not available.

Source: Industrial Minerals.

TABLE 3

U.S. EXPORTS OF ZIRCONIUM, BY CLASS AND COUNTRY[1]

		2008		2009	
Class and country	HTS[2]	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ore and concentrates:	2615.10.0000				
Belgium		2,530	$2,940	6,580	$6,850
Brazil		2,920	4,070	188	186
Canada		2,560	2,700	1,770	2,090
Colombia		1,550	2,000	697	909
Germany		2,090	2,980	870	1,240
Italy		355	395	156	232
Japan		2,040	4,060	11,600	6,520
Korea, Republic of		1,090	3,130	2,320	2,060
Mexico		9,860	7,000	4,010	4,140
Netherlands		11,200	9,590	9	53
United Kingdom		2,070	4,870	1,540	2,470
Other		3,840 [r]	7,420	9,830	9,590
Total		42,100 [r]	51,100	39,600	36,300
Ferrozirconium:	7202.99.1000				
Canada		72	167	54	122
Costa Rica		41	51	20	25
Guatemala		19	25	--	--
Mexico		128	253	490	983
Nicaragua		39	52	--	--
Other		16	27	1	10
Total		316	574	566	1,140
Unwrought zirconium, powders:	8109.20.0000				
France		16	1,020	37	1,730
Germany		11	347	11	356
Japan		12	501	6	347
Mexico		5	214	--	12
Russia		49	2,740	73	4,000
United Kingdom		211	4,190	24	730
Other		40	1,420	14	484
Total		344	10,400	165	7,660
Zirconium waste and scrap:	8109.30.0000				
Canada		49	2,790	27	1,590
France		13	171	12	208
Germany		36	581	--	--
Japan		29	783	--	--
Netherlands		44	507	--	--
Sweden		35	618	16	266
United Kingdom		27	705	--	--
Other		13	561 [r]	3	42
Total		247	6,720 [r]	58	2,110
Other zirconium:	8109.90.0000				
Canada		446	32,500	442	37,200
China		698	60,000	680	62,700
France		129	8,720	149	11,600
Japan		316	22,200	205	17,500
Korea, Republic of		136	15,700	287	26,100
Spain		92	13,600	83	14,300
Sweden		95	7,510	109	9,280
Other		167	13,100	122	11,100
Total		2,080	173,000	2,080	190,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF ZIRCONIUM AND HAFNIUM, BY CLASS AND COUNTRY[1]

Class and country	HTS[2]	2008 Quantity (metric tons)	2008 Value (thousands)	2009 Quantity (metric tons)	2009 Value (thousands)
Zirconium ore and concentrates:	2615.10.0000				
Australia		12,700	$9,530	8,090	$6,910
South Africa		19,600	14,900	5,080	7,390
Other		2,010	5,790	1,250	2,810
Total		34,400	30,200	14,400	17,100
Ferrozirconium, Brazil	7202.99.1000	129	594	(3)	7
Unwrought zirconium, powder:	8109.20.0000				
France		8	332	3	166
Germany		66	2,330	9	1,540
Other		20	121	9	190
Total		94	2,790	22	1,890
Zirconium waste and scrap:	8109.30.0000				
Australia		88	103	18	22
Canada		7	54	--	-
France		49	674	83	807
Japan		70	69	1	16
Other		11	141	327	1,050
Total		224	1,040	429	1,900
Other zirconium:	8109.90.0000				
Belgium		21	708	20	467
Canada		40	4,400	34	3,810
France		335	39,800	347	48,600
Germany		40	11,300	7	2,210
South Africa		240	280	86	112
Other		39	1,690	33	1,330
Total		715	58,200	526	56,500
Unwrought hafnium including powders:	8112.92.2000				
France		6	1,410	4	1,910
Germany		5	1,770	--	23
United Kingdom		1	564	--	-
Other		(3)	111	1	153
Total		12	3,850	5	2,080

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 5
ZIRCONIUM MINERAL CONCENTRATES: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2005	2006	2007	2008	2009
Australia	427,000 [4]	492,000 [4]	601,000 [4]	550,000 [4]	476,000 [4]
Brazil[5]	25,657 [4]	25,120 [4]	26,739 [4]	17,682 [r, 4]	18,134 [4]
China	120,000	135,000	140,000	140,000	130,000
India	26,700 [4]	28,000	29,000	30,000	31,000
Indonesia	2,600	65,000	111,000	65,000	63,000
Malaysia	4,954 [4]	1,690 [4]	7,393 [4]	7,000	7,000
Russia[6]	6,700	7,500	7,136 [4]	7,000 [4]	5,000 [4]
South Africa	376,000	398,000	400,000	400,000	392,000
Ukraine	35,000	35,000	35,000	35,000	35,000
United States	W	W	W	W	W
Vietnam	32,500	26,100	22,000	22,000	7,000
Total[7]	1,060,000	1,210,000	1,380,000	1,270,000 [r]	1,160,000

[r] Revised. W Withheld to avoid disclosing company proprietary data; not included in total.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes data available through April 30, 2010.

[3] Small amounts of zirconium concentrates were produced in various countries; however, information is not sufficient to estimate output.

[4] Reported figure.

[5] Includes production of baddeleyite-caldasite.

[6] Production of baddeleyite concentrate averaging 98% ZrO_2.

[7] Does not include U.S. data, which are withheld to avoid disclosing company proprietary data.

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